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OR

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PHILADELPHIA.

PRINTED AND PUBLISHED BY M. CAREY & SON.

No. 126, CHESNUT-STREET.

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May 1, 1817.

PREFACE.

No. 11, *Compton Street, Soho.*

THE following pages are intended to exhibit a summary view of the general nature of chemical reagents or tests, with the effects and phenomena which are produced by the action of these bodies—the particular uses to which they may be applied in the various pursuits of chemical science—and the art of applying them successfully.

To accomplish this object, I have in the first place stated the characteristic powers of each individual test, and have afterwards proceeded to illustrate its attributes, and peculiar mode of action, by a series of experiments, sufficiently striking to interest the mind, and imprint its generalities on the memory.

In selecting the illustrative proofs, I have chosen such experiments only as are easy to be performed, and the exhibition of which requires no other agents, than a mere collection of the chemical tests enumerated in the treatise, in addition to a few articles of commerce, which may readily be procured.

I have given a list of all those substances for which there exist any appropriate tests, with direct refer-

ences to the manner in which those substances may individually be detected.

And I have also pointed out the precautions necessary to be observed, to guard against deceitful appearances that may occur under certain circumstances, and without which precautions chemical tests are of little utility.

In fact, I have not only endeavoured to render this treatise useful to the young chemist, but it has also been my aim to give it such a popular form, as to place the subject on which it treats within the reach even of those, who are unacquainted with the principles of chemical science.

The student, in particular, will, it is presumed, readily comprehend the signals by which the chemist steers; he will find no difficulty in applying chemical re-agents to original investigations, whilst, at the same time, he will become enabled to perform a series of amusing and instructive experiments, well calculated to illustrate the chemical affinities of different bodies, and the most important changes of which they are susceptible in their reciprocal action —he will thus become acquainted with the laws that govern the composition and decomposition of bodies, and with the practical processes by which the constituent parts of compound bodies are discovered.

FREDRICK ACCUM.

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GENERAL nature of Chemical Tests—purposes for which they are employed—phenomena arising from the action of these bodies—upon what founded—manner in which they indicate the absence or presence of the substances, for the detection of which they are employed—precautions to avoid fallacious results—services they render to the practice of chemistry were first used by Boyle in 1663, who was acquainted with the tests for detecting acids, alcalies, copper, silver, mercury, &c. —Duclos, in 1666, employed re-agents in the chemical examination of mineral waters—further pursuit of the subject by modern philosophers.

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EXPERIMENT CIII. - - - - - 106
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XXVI. MURIATE OF PLATINA 110

Is a capital re-agent for discriminating potash from soda—conditions to render its power energetic.

EXPERIMENT CV. - - - - - 110
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XXVII. GREEN SULPHATE OF IRON 111

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EXPERIMENT CIX. - - - - - 112
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XXVIII. ARSENIOUS ACID 113

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EXPERIMENT CXI. - - - - 114

XXIX. MURIATE OF GOLD 114

Is used as a test for tin—and for detecting albumen—is of no great value for the latter purpose.

XXX. SULPHATE OF COPPER 114

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EXPERIMENT CXII. - - - - - 115

XXXI. MURIATE OF LIME 116

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XXXII. BENZOATE OF AMMONIA 117

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EXPERIMENT CXIII. - - - - 121
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XXXIV. TINCTURE OF GALLS 122

Is an excellent test for detecting iron—observations on its effects.

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XXXV. SULPHATE OF COPPER AND AMMONIA 127

A test for arsenic.

EXPERIMENT CXXIII. - - - - 127
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XXXVI. SUB-BORATE OF SODA

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XXXVII. SUB-MURIATE OF TIN 128

Is a test for platina—gold—and for albumen.—Observations on its power—important remarks of Mr. Phillips.

EXPERIMENT CXXV. - - - - 129
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——————— CXLVI. - - - - 147
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XLI. PRUSSIATE OF AMMONIA 150

Is particularly useful in the analysis of certain classes of salts, with alcaline and metallic bases—advantages of its application.

XLII. PRUSSIATE OF MERCURY 151

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XLIII. BARYTIC WATER 152

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tia from barytes—precautions to be observed in its application—also useful for purifying rain water so as to render it fit for chemical purposes—preparation of it.

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EXPERIMENT CLVI. - - - - 158
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EXPERIMENT CLXXVII. - - - 177
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LIST OF SUBSTANCES

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A

PRACTICAL ESSAY, &c.

DEFINITION AND GENERAL NATURE OF CHEMICAL TESTS.

Chemical tests, or Re-agents, are called those substances, which, when applied to other bodies, the nature or composition of which are unknown, *quickly* act upon them, and produce such changes as are sufficiently striking to the senses, and from which the quality or nature of the unknown body may be inferred.

As the chemical affinities of bodies towards each other are various, the constituent parts of compound bodies may be easily disengaged by other substances; and it is upon this consideration that the action of all the Re-agents or tests employed by chemistry in its analysis is founded. For the great object of acquiring a knowledge of the chemical nature of bodies consists in separating their component parts; but this is seldom practical, without, at the same time, uniting them to another body, and it is this that leads to the object in view, namely, the know-

ledge of the composition of the substance under examination. It is thus that Re-agents frequently act. The test combines with some principle of the body with which it is brought into contact; and a compound arises, whose characters at once indicate to us the nature of the principle which has entered into combination, because the combinations of the principal Re-agents with various bases are well known. Sometimes the Re-agent displaces from the body under examination certain constituent parts or principles only; which in that state may be examined more accurately, and with less trouble, because insulated and disengaged from their combinations.

It likewise frequently happens, that the Re-agent made use of is itself decomposed, which circumstance renders the phenomena and the products more complicated; but we are enabled from the characters of these products, and their actions upon other bodies, to form a judgment of the component parts of the body analysed. This last fact was little attended to by the ancient chemists; and this is one of the principal defects of their labours; because they referred many of those phenomena to the bodies which they submitted to their analysis, which in reality arose only from the decomposition of the Re-agents employed in their operations.

Most of the tests employed in the processes of chemistry indicate the component parts of bodies, by occasioning either a precipitate, a sensible cloudiness, a change of colour, an effervescence, or such

other alterations of properties, as experience has proved denote the presence or absence of certain bodies.

It may be readily conceived, that a vast variety of substances, provided their chemical actions be well established, may serve as Re-agents or tests, and that even no compound is useless to a skilful chemist in his analytical operations. But by long search and experience we have learnt to make a choice of some particular bodies only, the effects of which are rapid, and the application of which requires no skill, and to these bodies the name of Re-agents, or tests, has been given by mutual consent.

There are, however, two circumstances, which render it necessary that the substances used as tests should be applied with care and circumspection; one is, that the same body used as a Re-agent frequently produces a similar apparent effect, on two, three, or more different matters contained in the compound to which it is presented; the other, that one Re-agent may produce several of those effects with one and the same substance. Both these inconveniences may be remedied, by employing and comparing the effects of several of the Re-agents, and by assisting their action by other agencies, calculated to render the results unequivocal. This mode of proceeding, the only one that can render the use of chemical tests much more certain and advantageous, therefore supposes that we do not precisely fix certain

specific tests for certain specific substances under all circumstances, and that we take the facts we are in search of, from the united effects produced by the summary action of several tests, applied under different circumstances, as will be pointed out in the sequel.

The application and importance of the substances made use of, as Re-agents, was first pointed out by the illustrious Boyle. It had long before been known, indeed, that the blue colour of violet flower was reddened by sulphuric acid, lemon juice, and vinegar; but this philosopher proved that the reddening property belonged to all acids, and that it was a leading property which characterises this class of bodies. He was also the first who observed that alcalies render the blue colour of vegetables green, which he instances in the juice of the flowers of the blue-bell, and the blue Iris. He mentions the effect of volatile alcali or ammonia, in producing a blue transparent fluid, with solutions of copper, and he relates that the colour of rose leaves is destroyed by the fumes of burning sulphur or sulphurous acid; but heightened by sulphuric acid. That water tinged red with Brazil wood becomes yellow by acids, and that alcalies restore the original colour of the tincture: that silver is precipitated from its solutions by common salt and sulphuric acid, and that the precipitate is blackened on exposure to the rays of the sun, or the mere light of day. That sulphate of mercury acquires a yellow colour by the affusion of boiling

water; that quicksilver dissolved in nitric acid occasions an orange coloured precipitate with fixed alcalies, and that metals and metallic solutions become blackened by sulphurets of all kinds. He also points out the effects of lime water, and acetate of lead, as tests for various bodies, and he describes the compounds which they produce.

Soon afterwards, namely, in the year 1665, M. Duclos employed tincture of galls, sulphate of iron, and tincture of litmus, as Re-agents in the analysis of some mineral waters of France; and made some useful critical remarks on the golden colour given to silver by sulphureous waters, and on other Re-agents which had begun to be employed, and recommended by Boyle.

In 1685 Boyle again gave some new instructions for using the tests which he had pointed out in the year 1663, and he strongly recommended his *fuming liquor* (hydro-sulphuret of ammonia,) as a test useful in the analysis of mineral waters; as well as solutions of sea salt, sal ammoniac, nitric acid, muriatic acid, and ammonia, which he extolled as deserving the notice of the chemist. And from that period chemical re-agents were employed, but the conclusions drawn from their effects were long inaccurate and erroneous.

The list of chemical Re-agents, however, has been greatly augmented by the labours of modern chemists, and we are particularly indebted to Bergman, Scheele, Kirwan, and Westrumb, for the knowledge

of the particular actions of numerous Re-agents, and the modes of applying them with success in the multifarious researches of chemical science.

The following are the most essential tests now made use of in chemistry.

LIST OF CHEMICAL TESTS.

I. TINCTURE OF LITMUS.

This test is employed for detecting the presence of uncombined acids, by which it becomes changed to red; its natural colour being a dark blue, inclining to purple. If the redness vanishes by suffering the fluid to stand exposed to the open air, or when concentrated by boiling, and re-appears by a fresh addition of a portion of the fluid, we then are sure that the acid is either carbonic acid gas, or sulphuretted hydrogen gas; a substance which, in this, as well as in every other case, performs the function of an acid. If the redness is produced by carbonic acid gas, the fluid becomes *immediately* turbid by the admixture of barytic water, and a precipitate falls down, which is soluble with effervescence in pure dilute muriatic or nitric acid. But if the redness is owing to sulphuretted hydrogen gas, no precipitate takes place, and this forms a decisive criterion to distinguish the action of carbonic acid gas upon litmus, from that of sulphuretted hydrogen gas. Besides, a fluid containing sulphuretted hydrogen gas, even when the portion of the gas is very small, always exhales a

strong fœtid odour, resembling that of putrid eggs. A drop of nitrate of silver, super-acetate of lead, or muriate of bismuth, render it instantly *black*, but no such effect is produced with carbonic acid gas.

If the reddened tincture of litmus does not become blue again, after it has been suffered to stand exposed to the free contact of air, or, better, when it has been concentrated by boiling to about one half of its original bulk, we are then sure that the redness is occasioned by a fixed acid, the nature of which may be ascertained by other tests; as will be pointed out hereafter.

EXPERIMENT I.

Into a test tube* half filled with distilled water, let fall a drop or two of tincture of litmus; the blue colour of the tincture will not be altered.

EXPERIMENT II.

Add to a wine-glass full of distilled water impregnated with carbonic acid gas, (for the mode of preparing this water, see index, or take common seltzer water of commerce,) a small quantity of the tincture

* *Test tubes* are called glass tubes, three or four inches long, and from 1-2 inch to 3-4 of an inch in diameter, closed and rounded off at one end, and open at the other, with a rim a little turned over, to pour liquids out from them conveniently. They are useful for observing the changes of colour, and the phenomena produced by the action of chemical tests, as well as for dissolving solids, precipitating solutions, &c. A series of these tubes are usually kept in the Laboratory, arranged in a wooden stand; and are of great utility to the chemical operator. They will bear heat without cracking.

of litmus, its colour will become changed to red. Put the water into one of the evaporating basins contained in the chest, place the basin on the ring over the lamp-furnace, and evaporate it, by the heat of the spirit lamp, to about one-third or one-half of its bulk. The tincture will, during this process, recover its original blue colour, because the carbonic acid gas becomes volatilized, and the litmus is left behind in its natural state.

EXPERIMENT III.

To show the extreme sensibility of this test, with regard to carbonic acid; let a few ounces of distilled water be tinged slightly blue, by tincture of litmus, and blow, through the coloured water, the breath from the lungs, by means of a quill or tobacco-pipe, dipping into the fluid. The bubbles of air, expired, whilst passing through the water, will speedily produce the reddening effect; though the quantity of carbonic acid gas, contained in the air breathed out from the lungs, does amount only to 8 or 8 1-2 per cent. If the water thus reddened be boiled, its original blue colour will re-appear, as in the before mentioned experiment.

EXPERIMENT IV.

Let fall into a test tube half filled with distilled water, a drop of lemon juice, vinegar, or any of the acids contained in the chest, and add to the mixture a few drops of tincture of litmus; the tincture will instantly become changed to red; boil this fluid as

before directed, and its colour will not vanish, but remain permanent, because the redness is owing to a fixed acid.

EXPERIMENT V.

Add to the same quantity of distilled water, a grain of allum, salt of sorrel, or cremor tartar; no change will take place; but if a few drops of tincture of litmus be added, the fluid instantly becomes red; because these salts contain a portion of a free or uncombined acid.

EXPERIMENT VI.

Impregnate distilled water with sulphuretted hydrogen gas, (see index the article sulphuretted hydrogen) and add to half a wine glass full of it a little tincture of litmus. The fluid will exhibit a red colour; boil the reddened tincture, and it will be seen that it first loses its colour, or nearly so; but on continuing the heat, the fluid will become blue again; because the sulphuretted hydrogen gas is now volatilized.

EXPERIMENT VII.

To contrast the action of sulphuretted hydrogen gas, with that of carbonic acid gas, upon tincture of litmus, provide two test tubes containing dilute tincture of litmus reddened by carbonic acid, and two other tubes half filled with the same tincture, reddened with sulphuretted hydrogen gas. Drop into one of the first tubes, containing the carbonic acid water,

a little barytic water, which *immediately* will produce a cloudiness, which again disappears by the addition of dilute nitric acid; and in the other tube containing the same tincture, let fall a few drops of nitrate of silver, which will produce no effect. This being done, drop barytic water also into one of the tubes containing the tincture of litmus reddened by sulphuretted hydrogen gas, no precipitate will follow, and if nitrate of silver be dropt into the other tube, a black precipitate will instantly be produced.

It is often better, particularly in the examination of mineral waters, not to content ourselves with adding a few drops of the test to a small quantity of the liquid, but to treat the mineral water with the Reagents in the large way; by so doing we are enabled to observe the phenomena which the test produces more distinctly, whilst at the same time, when a precipitate is produced, as is frequently the case, we obtain of it, a quantity more convenient for extending our examination.

The following method of employing tincture of litmus in the analysis of mineral waters is recommended by Dr. Philips Wilson, in his analysis of the malvern waters; it shows the superiority of the application of chemical tests in the large, wherever the nature of the subject will admit of it.

EXPERIMENT VIII.

Let two glass basins of the same size, with cylindrical sides and flat bottoms, of at least four inches

diameter and three inches high (finger glasses, such as are used at table,) be placed on a sheet of white paper, and another sheet of white paper placed behind them, and let the observer stand between the glasses and the side from which the light comes, that he may receive the incident light reflected from behind and below the glasses. Let one of the basins be filled to about one or two inches in height with the water or liquid in which we suspect the presence of an acid, and let the same quantity of distilled water be put into the other glass basin, and to each let the same number of drops of tincture of litmus be added, taking care that the quantity of litmus be no more than is sufficient to give the slightest tinge, to show decidedly the purple blue colour in the distilled water. By comparing the colour of the water in the two basins, a very minute quantity of acid may thus be detected, especially by a person accustomed to use the test in this way.

Mr. Kirwan could not discover more than 1-12,000 of sulphuric acid by litmus. By the foregoing mode of using this test, it is rendered many times more sensible, as will appear from the following experiment.

EXPERIMENT IX.

To two ounces of water, sulphuric acid was added in the proportion of 1 to 307200. This was put in one of the glass basins placed as above; and in the other basin, two ounces of water, which, from

previous experiments, had been found did not affect the colour of litmus. On dropping into both basins the same quantity of the test, the colour was sensibly redder in the basin which contained the acid than in the other; the difference was such as could be readily observed by a person accustomed to make such experiments.

When the acid was not diluted in the proportion of 1 to 460800, no difference of shade could be observed. The specific gravity of the acid employed by Dr. Wilson was 1,85. which is the usual strength of the acid of commerce, so that one grain of this acid contained 0,7946 grains of real acid, as nearly as can be ascertained from Kirwan's table of the specific gravity of sulphuric acid mixed with different proportions of water, and hence it therefore appears, that 0,7946 grains of sulphuric acid may be detected by the litmus, when used in the manner stated, in 307200 grains of water, so that one grain of real sulphuric acid may be detected by this test in 386597 grains or 50,33 pints of water.

Tincture of litmus, when kept for several months, in a stopt bottle, loses its colour, and acquires an olive brown tint; but it speedily regains its original blue colour, when the bottle is opened, and suffered to stand exposed to the air for a few minutes. If the colour of this tincture inclines too much to purple, add to it a few drops of liquid ammonia, but of this fluid no more must be mixed with the tincture, than is barely suf-

ficient to produce the desired effect, otherwise the sensibility of the test is impaired.

II. LITMUS PAPER.

Paper stained with tincture of litmus is also used as a test for detecting acids, in an uncombined state, by all of which it is reddened. If the redness is occasioned by carbonic acid gas, the paper, like the tincture with which it is stained, regains its original colour on drying, or by exposure to a gentle heat; whereas all other acids redden it permanently.

Water impregnated with sulphuretted hydrogen gas likewise produces an evanescent feeble redness with the rest.

EXPERIMENT X.

Dip a piece of litmus paper into distilled water, and its blue colour will not be altered.

Dip a piece of the same paper into water impregnated with carbonic acid gas, (or into common seltzer of commerce) the water will acquire a reddish tint, and in a few minutes the blue colour of the paper will also be changed to red. Remove the paper and dry it near a fire, and its original colour will reappear, because the carbonic acid which produced the redness is volatilized.

EXPERIMENT XI.

Add a few drops of sulphuric, nitric, or muriatic acid, to half a wine glass full of distilled water, and

dip into the fluid a slip of litmus paper. Its blue colour will in a like manner be changed to red.

Take the paper out of the water and dry it in a warm place; its original blue colour in this case will not re-appear, because the acid which produced the redness cannot be volatilized by mere heat.

EXPERIMENT XII.

Immerse a slip of litmus paper into any sort of wine, cider, perry, ale, porter, or other kind of fermented liquor, its blue colour will become changed to red, because all vinous fluids, even the mildest, contain a portion of a free acid; some more, others less. The paper thus reddened will not become blue again on exposure to heat. The redness occasioned by vinous liquors in tincture of litmus, is owing to the presence of citric, tartaric malic, or acetic acid.

EXPERIMENT XIII.

Dip a piece of litmus paper into water strongly impregnated with sulphuretted hydrogen gas; its blue colour will gradually be changed to a faint red, dry the paper, and its original colour will re-appear.

Paper stained with the juice of the violet flower, or the scrapings of purple raddishes, answers the same purpose.

The colour of litmus paper ought to be a pale, not dark, violet blue. This paper, when long kept exposed to the contact of air and light, loses its colour, and then becomes unfit for use. It should there-

fore be preserved in opake stopped bottles, or placed between the leaves of a book.

Litmus paper is readily prepared, by dipping fine writing paper into tincture of litmus, and suffering it to dry slowly. The paper employed should first be freed from the portion of glue, alum, and other foreign matters, which all writing paper contains, which may be done by a repeated affusion of distilled water.

This test paper is reddened by water, containing 1-4695 part of sulphuric acid.

III. LITMUS PAPER REDDENED BY VINEGAR.

Litmus paper when slightly reddened by an acid, has its blue colour restored by alcalies, their carbonates, and alcaline earths, because the acid which caused the redness is again neutralised, and consequently its action destroyed; so that in this instance, as usual, acids and alcalies are in direct opposition to each other, the acid restoring the colour to its original state, after it has been changed by the alcali, and *vice versa.* A single coloured test paper of litmus becomes therefore a delicate test, for both acids and alcalies.

To know whether the effect which this paper suffers be owing to an alcali, or to lime, dissolved in carbonic acid, it is necessary that the fluid be evaporated to at least one half of its original bulk, before the test paper is applied; because the excess of carbonic acid, with which lime can only exist in solu-

tion, becomes then volatilized, and the lime combined with a smaller portion of carbonic acid can no longer exist in the liquid, but is precipitated in the form of a white powder, or neutral carbonate of lime: the heat applied having annihilated the bond of union which existed between the neutral carbonate of lime, and the excess of carbonic acid.

But if the blue colour of this paper still continues to re-appear, after the liquid has been concentrated by boiling, there is then reason to believe, that the reddening cause is owing to a fixed alcaline salt. The nature of which may be discovered by tests employed for discovering these bodies; and the action of barytes and strontia may be rendered obvious by other means.

EXPERIMENT XIV.

To one quarter of a pint of distilled water, strongly impregnated with carbonic acid gass, (or to common seltzer water) add about 15 or 20 grains of finely pulverised white marble or chalk; let the mixture stand for some hours closely corked, and shake the bottle frequently during that time. Part of the calcareous earth, of the marble or chalk, will become dissolved in the water. When the fluid has become clear, decant part of it, or better filtre it, and immerse into the solution a piece of litmus paper reddened by an acid; the tint of the paper will gradually vanish, and its original blue colour will re-appear

EXPERIMENT XV.

Take another portion of the same water, and evaporate it, by means of the lamp-furnace, to at least one half of its bulk. During this process it will become turbid, a multitude of minute air bubbles will become disengaged, and the carbonate of lime, which was dissolved in the water by virtue of its excess of carbonic acid gas, becomes again precipitated in the form of a neutral carbonate of lime, when the excess of the carbonic acid is volatilized.

When the precipitate has subsided let the water be filtred, and immerse into it a piece of reddened litmus paper; the colour of which now will no longer be altered.

EXPERIMENT XVI.

To a test tube full of distilled water, add a few grains of sub-carbonate of potash, soda, or any other alcali, and dip a piece of reddened litmus paper into this solution; immediately the red colour of the paper will vanish, and its original blue colour will reappear. Evaporate another portion of the same water to one half of its bulk, and examine it again with the reddened paper; notwithstanding the evaporation, the red colour will disappear, and the blue be restored.

EXPERIMENT XVII.

Dip a piece of litmus paper slightly reddened with an acid, into half a wine glass full of distilled

water, to which previously a few drops of liquid ammonia have been added; the red colour will vanish, and the paper regain its original blue colour.—Remove the paper near a fire, the blue colour will now disappear, and the red colour become restored.

EXPERIMENT XVIII.

Litmus paper reddened by an acid has also its colour restored by alcaline earths, namely, by barytes, strontia, &c. as may be seen by dipping the paper into barytic water, &c. To discriminate whether the change be owing to one of these bodies, or to the action of alcalies, or carbonate of lime with excess of carbonic acid, add to the solution, largely diluted with distilled water, a drop of sulphuric acid, which will occasion a precipitate if the effect be owing to the presence of barytes or strontia, for these bodies instantly produce with sulphuric acid an insoluble precipitate; whereas carbonated alcalies, namely, potash, soda and ammonia, as well as lime, are not effected by it.

This test paper also suffers a change after long exposure to air and light. It may be easily prepared by adding vinegar, or any other acid, to tincture of litmus, just in sufficient quantity, and no more, to change the blue colour of the tincture red, and then staining paper with it, as directed page 22; or by passing blue litmus paper through distilled vinegar.

IV. TINCTURE OF RED CABBAGE.

This tincture, which is of a bright blue colour, is an exceedingly delicate test both for acids and alcalies, when present in an uncombined or free state.—A very minute portion of any alcali changes its vivid blue colour to green, whilst acids turn it red.—The alcaline earths, barytes, strontia, and lime, here also act as alcalies.

EXPERIMENT XIX.

Add to half a wine glass full of tincture of red cabbage, a small quantity of the white of an egg, either in a liquid state, or rendered concrete by boiling. The tincture will lose its blue colour and become changed to green, because the white of the egg contains soda.

EXPERIMENT XX.

Let distilled water be tinged blue, by adding to it tincture of cabbage, and fill with this coloured fluid two test tubes. Drop into one of them a little lemon or orange juice, which will instantly change the blue colour red, and by adding the minutest quantity of subcarbonate of potash, or any other alcali (contained in the chest,) to the other tube, the blue becomes changed to green.

The action of barytes, strontia, and lime, need not to be illustrated, because they act precisely like alcalies upon this tincture, and we are in possesson of ex-

cellent tests for discriminating these bodies, as will be seen hereafter.

Tincture of cabbage is very liable to spoil; it soon undergoes a kind of putrefaction, which destroys its colour. It is obtained by cutting fresh leaves of the red cabbage (brassica rubra) into small pieces, and pouring over it boiling-hot distilled water, and suffering the whole to macerate for a few hours. The clear fluid being then decanted and mixt with one-eighth of its bulk of spirit of wine, is fit for use.

The cabbage leaves may be preserved for many years, by drying them in a warm place, at a temperature of about 120° F, having previously cut them into small pieces.

To prepare the test liquor from the dry leaves, let them be digested in distilled water, to which a minute portion of sulphuric acid has been added, which will produce a red tincture. Then let the acid be neutralized by marble powder, the red colour will vanish, and the tincture become blue. This being done, suffer the mixture to become clear by subsidence, or filtre it; and lastly, mingle it with one-eighth of its bulk of spirit of wine. The test thus prepared keeps much longer than when obtained from the fresh leaves of the plant.

V. TINCTURE OF BRAZIL WOOD, AND BRAZIL WOOD PAPER.

Tincture of Brazil wood, which is of a fine dark red colour, becomes changed to violet or purple, by

alcalies, either in a pure state, or when combined with carbonic acid; and also by alcaline earths. It is, however, liable to mislead, because a solution of magnesia, or calcareous earth, with excess of carbonic acid, produces a similar change. If, therefore, the test be employed in the analysis of a mineral water, containing supercarbonate of lime, or magnesia, these substances should first be got rid of, by concentrating the water by boiling, or the excess of the carbonic acid which held these earths in solution flies off, and the neutral carbonates fall down, see page 23. If the test be then applied to the filtred water, we may know whether the change of colour is produced by a free or uncombined alcali, or by a carbonated earth. If by the former, the purple colour becomes more intense, because the evaporated water holds a greater quantity of alcali in solution than it did in its natural state; but if the change be produced by a carbonated earth, the effect will be the reverse. Besides this, gypsum, or sulphate of lime, is also capable of altering the colour of this test. The paper coloured with tincture of Brazil wood is usually employed instead of the tincture, it being more convenient for use.

EXPERIMENT XXI.

Into distilled water dip a piece of Brazil wood-paper; its red colour will not be altered.

EXPERIMENT XXII.

Add to half a test-tube full of the same water, a grain of subcarbonate of potash, or any other alcali, and into this solution immerse a slip of Brazil wood paper. Its red colour will instantly be changed to violet.

EXPERIMENT XXIII.

Dissolve into distilled water impregnated with carbonic acid gas, some calcareous earth, for example, powdered chalk, or marble, see page 40, and let the water stand to settle. Put into the clear solution of carbonate of lime in carbonic acid, a piece of Brazil wood paper, and the red colour will gradually be changed to a very pale violet.

Let another portion of the same water be evaporated to one half of its bulk, and when cold filtre it, and dip into the filtred fluid Brazil wood paper, which now no longer will suffer a change of colour.

EXPERIMENT XXIV.

Shake up for a few minutes, 20 or 30 grains of chalk or marble powder, with 2 or 3 ounces of distilled water, to which previously 6 or 8 drops of sulphuric acid have been added. Part of the chalk becomes dissolved in the sulphuric acid, and the water will contain sulphate of lime. After the solution has been suffered to stand for five or six hours, or till it is clear, let it be filtered, and dip into it a piece

of Brazil wood paper, the colour of which will be changed to a faint violet.

EXPERIMENT XXV.

Add to half a test tube full of distilled water, a few drops of liquid ammonia, and let fall some drops of this fluid upon a slip of Brazil wood paper. It will produce brown stains, which will vanish again when the paper is held near the fire; because the ammonia becomes volatilized.

Brazil wood paper, when rendered violet by a dilute solution of an alcali, may be used as a test for acids, which cause the original red colour to re-appear.

VI. TINCTURE OF TURMERIC, AND TURMERIC PAPER.

This is an excellent test for discovering the presence of alcalies. The colour of the tincture is an intense yellow; it is changed to a brick red, or orange, by alcalies, whether in a caustic state or combined with carbonic acid, but it is not effected by carbonated earths; so that by this test we are at once enabled to distinguish the presence of a carbonated alcali, from a carbonated earth, when held in solution by an excess of carbonic acid.

Paper stained a pale yellow with this tincture, being more convenient in its application than the tincture itself, is usually employed in the laboratory.—

By means of it, the exact point of saturation of acids with alcalies may be ascertained with great nicety, which is often of considerable consequence in chemical operations.

EXPERIMENT XXVI.

Dip a piece of turmeric paper into distilled water, its yellow colour will remain unaltered.

EXPERIMENT XXVII.

Add a grain of potash, or soda, either in a pure state, or in the state of a carbonate, to half a test tube full of distilled water, and immerse into the solution a piece of turmeric paper, it will instantly acquire a brown colour; and if the paper be now dipped into a dilute acid, its original yellow colour will re-appear.

EXPERIMENT XXVIII.

Hold a piece of turmeric paper, slightly wetted with distilled water, over the open mouth of the bottle (in the chest,) containing liquid ammonia. The colour of the paper will become changed to brown, remove the paper, and hold it near the fire, the brown colour will vanish, and its original yellow colour will re-appear; because the ammonia becomes volatilized.

EXPERIMENT XXIX.

To seltzer water, (or distilled water impregnated with carbonic acid gas) add a portion of marble powder or chalk, shake the mixture in a stopped phial

frequently, during the space of twelve hours, to effect a solution of carbonate of lime; and lastly, filtre it, or suffer the mixture to stand undisturbed till it is become transparent. Dip into this solution of super-carbonate of lime, a slip of turmeric paper; its yellow colour will suffer no alteration. Hence this test paper is not changed to orange by carbonate of lime, but only by carbonated alcalies, and on this account it is preferable to Brazil wood paper, (page 31.) Barytes, strontia, and lime, act, as stated already, in this case also like alcalies.

The action of turmeric paper is very great, as may be seen from the following statement, which is copied from Dr. P. Wilson's analysis of the Malvern waters, p. 32.

EXPERIMENT XXX.

" Half a grain of carbonate of soda was dissolved " in twelve ounces of distilled water, which were " heated to 136°. Paper stained with turmeric was " allowed to remain in it for one minute at this tem- " perature. Its colour was not at all altered. This " water was gradually evaporated at a temperature " never exceeding 140°, and at short intervals slips " of paper stained with turmeric were dipped into it " and allowed to remain in it exactly a minute, and " as soon as the tinge it gave to the paper was deci- " dedly orange, it was removed from the fire and " measured; at this time the temperature was 124_o.

" —The quantity of water was found to be nine " ounces.

" Four ounces of Holy-well water were heated to " 136° ; at this temperature it did not affect the co- " lour of paper stained with turmeric, when allowed " to remain in it one minute. The evaporation was " continued in a temperature never exceeding 140°, " and gradually lessened to 124°, the slips of paper " being used at short intervals as before. When a " decidedly red tinge was observed, on allowing the " paper to remain in it for a minute in a tempera- " ture of 124°, it was removed from the fire and " measured: it was found to have lost just one fourth. " From this experiment it is evident the quantity of " carbonate of soda in a gallon of Holy-well water, " was easily calculated. The result is 5,33 grains.

" Half a grain of carbonate of soda was dissolved " in eleven ounces of distilled water, and exposed " to a temperature of 115°. The paper stained with " turmeric immersed into it; but I now measured " the water as soon as the least discolouration ap- " peared in the paper, after it had remained in it for " a minute in the above temperature, and found the " quantity to be ten ounces and a half.

" Four ounces of Holy-well water discoloured " the paper, allowed to remain in it for the same " length of time, in the same temperature, when one " eighth was evaporated. I was surprised, on making " the calculation, to find that this experiment gave " precisely the same result as the preceding, 5,33

" grains of carbonate of soda in a gallon of water, " that is, 128 ounces, and which quantity of alcali " was thus detected by turmeric paper."

Turmeric paper rendered brown, or orange, by alcalies, is restored to its original yellow colour by acids.

EXPERIMENT XXXI.

Dip a piece of turmeric paper into water, to which a little liquid ammonia has been added, the paper will become brown, remove it into water acidulated with sulphuric, nitric, acetic or muriatic acid, and its yellow colour will be restored.

Instead of turmeric paper, a fresh cut surface of the entire turmeric root may be wetted with distilled water, and by being rubbed on white paper, a very visible yellow mark will be made, on which a drop of the liquor to be examined may be put.

VII. SULPHURIC ACID.

Highly concentrated sulphuric acid discovers by a brisk effervescence, carbonic acid gas, when present in an uncombined state in any liquid, or when in combination with an earthly, alcaline, or metallic base. It is likewise used for decomposing the salts of lead and mercury, with which it produces a white precipitate. The precipitate obtained with mercury acquires a yellow colour by the affusion of boiling water. It is also a capital test for barytes and strontia, with both of which it forms highly insoluble compounds. This acid is frequently employed in

analytical experiments, for ascertaining the nature of certain classes of salts, so far, at least, as to discover the nature of the acid with which the base of the salt is united. But when used for that purpose, it is necessary that the saline compound to be examined be in a solid state, or at least nearly so. The salt to be assayed is covered with sulphuric acid, and the mixture warmed a little, a vapour or cloud will thus be produced; because the sulphuric acid expels the nitric muriatic, acetic, and fluoric acids, (besides many others) from their combinations. And as these acids are capable of assuming the gazeous state, and are condensible by moisture, they produce vapours with the moisture of the atmosphere; and from the nature of these vapours, the nature of the acid may be learnt. For example: If the salt belonged to the class of nitrates, the vapours produced by the action of the sulphuric acid have a yellow or orange colour, and the salt then deflagrates when laid on ignited coals. If the salt belongs to the class of muriates, the vapours are white; if it belongs to the class of acetates, the vapours have a strong smell of vinegar; and if they corrode glass, when suffered to be in contact with it for 10 or 20 minutes, the salt contains fluoric acid. Other tests may then be applied, to confirm or destroy the conjectures thus obtained by this agent. Sulphuric acid has also been recommended as a test for lime, when it exists in combination with certain bases, but it is of little value for that purpose, because the sulphate of lime which it

produces, being soluble in 500 parts of water, and much more so, when there is an excess of acid.—When employed for that purpose, the solution when highly concentrated is suffered to cool, the sulphate of lime then separates in long transparent crystals, which is a very common form for it to occur in chemical analyses. It is then distinguished by its want of taste, its difficult solubility when removed into pure water, and by its affording a precipitate with oxalic and barytic salts. When a liquor containing selenite is rapidly evaporated, this salt separates as a brittle shining laminæ.

EXPERIMENT XXXII.

To half a wine glass full of distilled water, add about 20 or 30 drops of sulphuric acid, and stir the fluid with a glass rod, the mixture will take place quietly, and no air bubbles become disengaged.

EXPERIMENT XXXIII.

Into the same quantity of water impregnated with carbonic acid gass, or to common seltzer water, add a like quantity of sulphuric acid. A multitude of very minute air bubbles will rapidly become disengaged, which indicate the presence of carbonic acid gas.

EXPERIMENT XXXIV.

Having dissolved 10 or 15 grains of muriate of soda (common salt) in about two tea-spoonfuls of water, add to it 10 or 15 drops of sulphuric acid.

White fumes will be disengaged; which indicate the presence of muriatic acid. And if a glass rod, or a feather, moistened with liquid ammonia, be brought near the mixture, the fumes will become more visible, and dense white clouds will be produced in the vicinity of the body, moistened with the liquid ammonia. The sulphuric acid decomposes the common salt, and expels one of its constituent parts; namely, the muriatic acid; which, as it becomes liberated, assumes the gazeous form, and would be invisible, if no humidity was present. But being condensed by the moisture which it meets with in the atmosphere, it appears as a cloud. The liquid ammonia producing dense white clouds, is owing to the production of muriate of ammonia, a salt, formed from the vaporous muriatic acid, combining with the volatilized ammonia, and thus producing muriate of ammonia.

EXPERIMENT XXXV.

Put into a small evaporating basin, 10 or 20 grains of pulverised nitrate of potash, (saltpetre) and pour upon it 20 or 25 drops of sulphuric acid; stir the mixture with a glass rod, and warm it gently over the spirit lamp. Yellow fumes will be produced, which indicate the presence of nitric acid. If a little of the salt be thrown on ignited coals, it will deflagrate.

EXPERIMENT XXXVI.

Put 10 or 20 grains of super-acetate of lead, or acetate of potash, into an evaporating basin, or tea-cup, and moisten it with sulphuric acid; a strong odour of vinegar will immediately become predominant, because the sulphuric acid expels the acetic acid from the super-acetate of lead, and unites with its base to produce sulphate of lead.

EXPERIMENT XXXVII.

Take common fluor spar (Derbyshire spar) reduced to powder, put about 1 ounce or more of it into a leaden basin (a piece of common sheet lead turned up at the edges so as to form a rim will answer the purpose) make it into a liquid paste with common sulphuric acid, and then heat the mixture over the lamp. Dense white fumes will become disengaged; and if a plate of glass be laid over the basin, it will speedily lose its polish, and become corroded by the vapour, or disengaged fluoric acid gas. In this manner etchings on glass may be made. The glass is to be covered over with hard engravers' varnish, called, etching ground, or bees-wax will answer the purpose, for the sake of experiment. When the coating is dry, the design intended to appear upon the glass is traced out upon the varnish or wax by means of a needle, or other sharp pointed instrument, as is done in common copper-plate etching; taking care that every stroke, or line, is carried clean, and smooth, through the coat of varnish or

wax, down to the surface of the glass, so that the light may be seen through the traces or cuts. If the glass, thus prepared, be exposed to the volatilized fluoric acid gas, by laying it over the basin, the etching will be made in 5 or 10 minutes.—The varnish or wax may afterwards be removed, by oil of turpentine.

The fluor spar consists of fluoric acid, united to lime, on adding to it sulphuric acid, which has a stronger affinity for lime than the fluoric acid has, the latter becomes disengaged in the gazeous state, and corrodes the glass in those parts where the varnish does not defend it from its action.

VIII. NITRIC ACID.

This acid is employed as a test for ascertaining in an expeditious manner, the purity of tin, for which purpose it is employed in the concentrated state; and when largely diluted with water, it becomes a test for readily distinguishing iron from steel. In the analysis of vegetable substances, the concentrated nitric acid assists us to discover *Resin.* For when concentrated nitric acid is digested repeatedly, with gum or mucilage, gluten, jelly, extract, gum-resin, or any other of the immediate vegetable products, it converts them into oxalic acid; whereas true Resin suffers no such change; and even after long digestion, this substance becomes only converted by means of nitric acid, into a pale, porous, orange coloured mass. And if nitric acid be repeatedly ab-

stracted from it, the result is not oxalic acid, but a deep orange coloured substance, which is soluble in water, and in alcohol: and although the resinous properties being lost, no vestige of oxalic acid can be discovered in the solution. Nitric acid is also used, to detect starch in vegetable substances. The substance is to be digested for some days in dilute nitric acid, and the solution mingled with alcohol; which throws down the starch from its solution in this acid. [Ann. de Chem. l. v. 28.]

And in the analysis of organic substances in general, nitric acid serves the purpose of a test for detecting the presence of azote or nitrogen, and thus it enables us to establish the presence of animal matter; because when this acid is made to act without the assistance of heat upon a substance, the nature of which is to be determined in that respect, azote, or nitrogen, is produced. For in fact we are not acquainted with any other ready method of discriminating in analysis, animal matter from vegetable matter; because we possess no other means of extracting azote, perfectly in its insulated state. The elements of animal matter are peculiarly prone to combination, and among them particularly the azote. The substance requires simply to be heated in a retort, and the gazeous product to be collected in the usual manner.—That the nitric acid did not furnish the azote, may be proved by saturating an aliquot portion of the acid employed in the experiment with an alcali, for it will be seen that the portion of acid thus tried satu-

rates as much alcali, as a like portion of the same acid, which has not been made to act upon the substance, consequently the azote must have been produced from the substance submitted to the action of the acid. Nitric acid is likewise useful as a test, for detecting uric acid, (in the analysis of urine) it produces with this substance a pink or rose colour.

EXPERIMENT XXXVIII.

Tin of commerce, frequently contains either a minute portion of copper or lead, and sometimes both these metals are present. To ascertain the purity of tin by means of nitric acid, put one part of the filing of the suspected metal into a basin or other convenient vessel, and add to it about three or four parts of nitric acid, a very violent action becomes exerted, the acid is decomposed with great rapidity, copious red fumes are disengaged, and the temperature of the mixture rises considerably. The tin becomes so highly oxidized, that it does not pass into a state of solution, but forms a white powder, in which, after having been washed, there are no traces of nitric acid, and which is therefore nearly a pure oxide.

When this has been effected, pour a small quantity of distilled water upon the mass, stir the mixture together, and suffer it to stand undisturbed, (or filtre it) till the super-natant fluid is become clear. Decant the clear fluid, and add to it liquid ammonia in excess ; if the tin contained copper, the fluid now will assume a blue colour. To assay it for lead, add to an-

other portion of the clear fluid, a few grains of sulphate of soda dissolved in water, which will occasion a white precipitate if lead be present, (sulphate of lead) which is highly insoluble in water, and therefore falls to the bottom.

EXPERIMENT XXXIX.

To distinguish iron from steel by means of this test, let the acid be diluted, with so much water that it will only feebly act upon the blade of a common table knife. If a drop of the acid thus diluted is suffered to fall upon steel, and allowed to remain upon it for a few minutes, and then washed off with water, it will leave behind a *black* spot. But if a drop of this acid be suffered to act upon iron, in the same manner, the spot will not be black, but of a whitish grey colour. The black stain is owing to the conversion of the carbon of the steel in charcoal, which thus becomes predominant, and iron being nearly free from carbon can produce only a grey stain.

The utility of this test is not confined to finished articles manufactured of steel, but its application enables the workmen in iron and steel, to ascertain also the *quality* and *uniformity* of texture of *unfinished* articles. The following observations of Mr. White show the utility of the test, to the workmen in steel and iron in general.

" It very frequently happens, that articles of con-
" siderable value, intended to be fabricated in iron or
" steel, are not known to be defective, until much ex-

"pense has been incurred in manufacturing them. "A piece of iron which has a vein of steel running "through it, as is too often the case, will require at "least three times the labour and care to turn out to "be fashioned in the lathe, which would have been "demanded by a piece of greater uniformity. Steel "which abounds with spots, veins, or specks, will "not show its defects until the final operation, when "the attempt is made to finish and to polish the "work. Other articles of steel, such as delicate "measuring or micrometer screws, blades of the best "kinds of sheers, fine circular cutters, engraver's "tools, surgical instruments, &c. either bend and lose "their shape in the hardening, from the difference "of expansion, or resist the tool when wrought in "the temperal state, or exhibit other incurable de- "fects when they come to be tried, which the test "by dilute nitric acid would have indicated be- "fore any expense had been incurred. In these, "and in numberless other instances, it would have "been incomparably more advantageous, to have re- "jected the material upon the first trial, than have "proceeded to the very expensive process of manu- "facturing the article, and then finding it of no value. "By this means I have seen bars of steel, which "were warranted by the vender as perfect, as full of "veins and irregularities as the coarsest wood, and "have been enabled to select the best and most uni- "form pieces for works of the greatest delicacy; "whereas, without this process, I have very often

" had the mortification to fail in the last stage of pro-
" cesses, upon which much cost and labour had been
" bestowed. It is only necessary to clean the rough
" article with a file, or emery paper, and then to ap-
" ply the nitric acid in a very dilute state; the parts
" which contain the greatest portions of carburet of
" iron will immediately show themselves by their
" dark colour." *Repository of Arts*, *No.* iv. *page* 202. 1816.

IX. MURIATIC ACID.

This acid may be used for detecting the presence of silver and lead, with the solutions of which it forms a white precipitate. The precipitate produced with silver becomes quickly blackened on exposure to light, it is perfectly insoluble in water, and soluble in liquid ammonia. The precipitate occasioned by lead suffers no such changes: it is soluble in about 22 parts of boiling water, and in dilute nitric acid.

It is also employed for discovering ammonia, when in a disengaged state; a glass rod or other substance, moistened with this acid, and held in the atmosphere of ammoniacal gas, becomes immediately surrounded by dense white clouds of muriate of ammonia, see page 53. It is likewise an useful auxiliary agent for ascertaining the presence of oxide of manganese in mineral substances; because it produces with it chlorine gas. Suppose a mineral be presented to us, and we wish to know whether it contains a notable quantity of oxide of manganese,

we may proceed in the following manner: 1st, Reduce the mineral to powder, pour upon it muriatic acid, and apply a moderate heat. If chlorine gas be disengaged in abundance, the mineral is chiefly manganese. 2d. To be certain of this, melt a little borax or soda in a platina spoon, add to it a little of the ore, and keep it melted by the *interior* flame of the candle. The colour of the mass in the spoon will be at first red, but this colour will gradually disappear if the ore be manganese. Now add a little nitre, or keep it melted for some time in the *exterior* flame, and the red colour will again appear, see Annals of Philosophy 1814, xxvi. p. 312.

EXPERIMENT XL.

Mix 5 or 6 drops of super-acetate of lead with half a wine glass full of distilled water, and add to it a drop or two of muriatic acid; a dense white precipitate will fall down, which is muriate of lead. This salt being soluble in about 22 parts of water, in which latter respect, as well as in not changing colour by a short exposure to light, it may be distinguished from muriate of silver, (see nitrate of silver) which it resembles; and water may therefore be used to separate the muriate of lead from that of silver, but nitric acid is preferable. The muriate of lead is likewise soluble in acetic acid, by which it may further be distinguished from muriate of silver, and from sulphate of lead. According to Klaproth, 100 grains dried fully, but short of volatilization, contain 75 of lead and 14 of muriatic acid.

EXPERIMENT XLI.

Mix a few grains of muriate of ammonia with double its weight of sub-carbonate of potash, or quick lime, intimately together, and bring near it a feather, or glass rod, moistened with muriatic acid, dense white fumes will become visible, which indicate the presence of ammonia. See page 53.

EXPERIMENT XLII.

Add a few drops of liquid ammonia to half a test tube full of distilled water, and moisten with this fluid a piece of paper, or any other substance. If a glass rod, or feather wetted with muriatic acid, be now made to approach the paper, dense white vapours will be formed.

For the action of muriatic acid, as a test for silver, see nitrate of silver.

X. TARTAREOUS ACID.

The two alcalies, namely, soda and potash, resemble each other so closely in their most obvious chemical characters, that they are not readily distinguishable but by studying the characters of their combinations: namely, by uniting them to acids, and examining the salts resulting from this combination. Thus sulphate of potash is a hard bitter salt, requiring a large quantity of water for solution, and therefore a saline precipitate of sulphate of potash is formed when the acid and alcaline solutions are somewhat concentrated, when mixt: whereas sulphate of soda is very soluble. Nitrate of potash crystallizes

in long six-sided prisms, but nitrate of soda in cubes. However, by means of tartareous acid this trouble may be saved, for it produces with potash when added in excess, a highly insoluble salt, but with soda a salt which is easily soluble in water. The alcali to be examined is first dissolved in muriatic or any other acid, and a solution of tartareous acid added in excess; if the salt has potash for its basis, there will be a chrystalline precipitate in a few seconds, but the mixture will remain clear if the basis of the salt is soda. But for the successful action of this test, it is necessary that the solutions of the salts be as concentrated as possible, and that the tartareous acid be always added in excess.

EXPERIMENT XLIII.

Make a concentrated solution of sulphate of soda in distilled water, and add to it a concentrated solution of tartareous acid; no change will take place, because the salts of soda are not altered by tartareous acid.

EXPERIMENT XLIV.

Make a concentrated solution of sulphate of potash in water, and add to it tartareous acid in excess; a chrystalline salt will gradually collect and fall to the bottom of the tube. The salt is super-tartrite of potash.

EXPERIMENT XLV.

Drop tartareous acid into a solution of phosphate of soda, no change will take place, for the same reason as stated in experiment XLIII.

EXPERIMENT XLVI.

Add to a solution of prussiate of potash, tartareous acid, and suffer the mixture to stand for a few minutes; minute crystals of super-tartrite of potash will be deposited on the sides of the vessel.

EXPERIMENT XLVII.

Dissolve five or six grains of caustic soda in half a test tube full of water, and add to the solution, tartareous acid in excess: no change will take place.

EXPERIMENT XLVIII.

Dissolve the same quantity of caustic potash in a like quantity of water, and add to the solution tartareous acid, in a few seconds the mixture will become turbid, and a quantity of white granular powder will fall to the bottom, which is super-tartrite of potash, and may be distinguished as such (when rinced with cold water) by feeling hard and granular in the mouth, with a slightly acidulous taste.

XI. BORACIC ACID.

The Boracic acid is employed in analytical chemistry, not directly as a re-agent or instrument of analysis, because its affinities and action have little energy compared with other acids. But it is of use to the mineralogist, as a flux for the blowpipe assay; it particularly facilitates the fusion of earthy substances; and produces with them a very limpid fusion. It is not volatilized by the most intense heat, and the

mass which it affords, with a vast number of mineral substances, does not readily sink into the pores of the charcoal upon which the assay is made. It may even be mixt with charcoal powder, without producing an incomplete vitrification. It is capable of dislodging all the acids, except the phosphoric, from their combinations, and at the same time from the colour which it produces, with different metallic oxides, &c. some conjecture may be formed, concerning the nature of the substance upon which it is made to act.

It is likewise a very useful agent for discovering the presence of alcalies in mineral substances, and has been recommended particularly for that purpose by sir Humphrey Davy. He fuses one part of the mineral under examination with two parts of boracic acid, dissolves the fused mass in dilute nitric acid, and concentrates the solution, to separate the silex. The liquid is then mixed with carbonate of ammonia in excess, boiled and filtered. By this means all the earthy and metallic ingredients are separated. The liquid is next mixed with a sufficient quantity of nitric acid, and evaporated till the whole of the boracic acid is separated. Nothing now remains but the nitric acid, combined with the alcaline constituents of the mineral, (and with ammonia) the nature of which may then be readily ascertained by tartareous acid, or muriate of platina, the nitrate of ammonia being first got rid of by an exposure to a dull red heat.

XII. ACETIC ACID.

Is occasionally employed as an auxiliary test for detecting the presence of ammonia, in the manner stated page 53. Acetic acid is of particular use in the analysis of vegetable substances, to separate resin from gluten, both of which are dissolved by acetic acid, but the latter remains in solution when water is added, and the former becomes precipitated. And as this acid does not, like the sulphuric and nitric acid, alter the resin when digested with it even for a considerable time, but lets this substance fall again apparently unaltered by the admixture of water, it affords a very useful re-agent in the complicated analysis of vegetable substances.

XIII. OXALIC ACID.

The oxalic acid is a test in chemical experiments to determine the presence of lime in liquids, in whatever combination this earth exists; for it attracts lime with greater force than any other acid, and therefore is capable of decomposing compleatly all the known calcareous salts. The oxalate of lime is insoluble in water; so that when this acid is added to a solution containing lime, a white precipitate of oxalate of lime falls down, from which, when collected, washed, and dried in a moderate heat, the actual quantity of lime may be readily inferred. But oxalate of ammonia is a better test for lime. See *Oxalate of Ammonia.*

Oxalic acid is also an useful re-agent, for separating oxide of iron from oxide of titanium; if a solution of this acid be added to muriate of titanium, a precipitate falls down, which is a pure oxalate of titanium, and which may be decomposed by exposure to a heat, sufficient to destroy the oxalic acid. This acid may likewise be employed for separating oxide of iron from oxide of cerium. If these two oxides exist together, it is only necessary to boil them in a solution of oxalic acid; the oxide of iron becomes dissolved, and the oxide of cerium remains behind in the form of a white powder, as oxalate of cerium; which may then be decomposed by heat. M. Laugier. Ann. de Chemie, t. 89, p. 306.

XIV. MURIATE OF AMMONIA.

This is one of the tests employed for detecting platina, with the solution of which it produces (if the platina be pure) a bright yellow precipitate, very slightly verging to orange. The precipitate is a triple compound, consisting of oxide of platina, ammonia, and muriatic acid. And by this character platina is distinguished from all other metals; and may be separated when combined with them. The precipitate, or triple salt, obtained by muriate of ammonia, when exposed to a strong red heat, furnishes a grey spongy mass, which is metallic platina.

This test therefore furnishes a ready expedient for detecting the adulteration of gold with platina, which

would elude the hydrostatic trial. The gold may be precipitated by a solution of green sulphate of iron, (see sulphate of iron) and the platina, by muriate of ammonia.

When this test is added to a solution of the *ore of platina*, in nitro-muriatic acid, the precipitate afforded by the first addition of muriate of ammonia is of a buff colour; and if the fluid above it, which is still of a reddish brown colour, be poured off, and muriate of ammonia again be added to it, a precipitate is thrown down of a bright orange colour; but no clear yellow precipitate can be obtained from the solution. The orange colour of the precipitate is owing to the presence of the metal called *Iridium*, which is associated with the ore of platina; a clear yellow colour of the precipitate is therefore a criterion of the purity of platina. The yellow precipitate forms an useful pigment for the painter, being a very bright and permanent colour.

Muriate of ammonia is also used as a test, to detect alcalies, and alcaline earths, all of which decompose this salt, and render obvious its ammonia. For this purpose the salt must be in a dry state, or nearly so, and a moderate heat may be employed to disengage the ammonia. But as many metals, and metallic oxides, are also capable of decomposing muriate of ammonia in the dry way, some collateral proofs must be employed, to render the presence of the alcali or alcaline earths unequivocal, besides

this we have better tests for alcalies and alcaline earths.

Mr. Chenevix recommends this salt as an useful agent for separating alumine from its alcaline solutions; the alcali combines with the muriatic acid; and the liberated ammonia determines the precipitation of the alumine, which, after being washed and dried, is perfectly pure.

EXPERIMENT XLIX.

Mix a little muriate of platina with half a test tube full of distilled water, and add to the mixture a solution of muriate of ammonia; a yellow precipitate will fall down, consisting of oxide of platina, muriatic acid, and ammonia.

EXPERIMENT L.

Mingle a solution of muriate of platina with a solution of muriate of gold, and drop it into the mixture a solution of muriate of ammonia, till no further precipitate ensues, and suffer the fluid to stand undisturbed till the super-natant fluid is become perfectly clear; it will still have a yellow colour. Add to it, a fresh prepared solution of green sulphate of iron, it will now again become turbid, or suddenly acquire a green colour, and a dark greenish, or rather a brown precipitate will slowly be deposited, which is metallic gold. If the precipitate obtained by muriate of ammonia be heated to redness by

means of the blowpipe, or (if the quantity be considerable) in the bowl of a tobacco pipe put into a common fire, metallic platina will be obtained in the form of a grey porous mass.

XV. OXY-MURIATE OF MERCURY, OR CORROSIVE SUBLIMATE.

This salt of mercury is employed as a test for indicating the presence of alcalies and alcaline earths. The fixed alcalies when caustic produce with it, a yellow; and carbonated alcalies, an orange coloured precipitate; lime water produces with it also an orange yellow precipitate. But this salt is seldom used, for we have better tests to discover alcalies.—Its action as a Re-agent in the analysis of animal substances is of greater value; for by means of it, we are enabled to detect minute quantities of albumen; a substance, which largely enters into the composition of many animal products. It produces with albumen, a white flocculent precipitate. It does not however separate the whole of the albumen, unless heat be employed, to assist the coagulation. And hence Dr. Bostock has proposed the following ingenious method of estimating the quantity of albumen contained in an animal fluid, viz. add to the fluid a quantity of oxy-muriate of mercury, more than sufficient to saturate the albumen, and then heat the

mixture. By this double action a coagulum is formed, which may be separated by the filtre. The precipitate is a compound of the metallic salt with albumen; in proportion of about one of the former to three or four of the latter. From the quantity of corrosive sublimate, therefore, required to decompose entirely a solution of albumen, we may infer the quantity of the latter; for three grains of the metallic salt, being entirely decomposed, indicate 10 1-2 grains of albumen.

There are other tests for detecting albumen; for instance sub-acetate of lead, and nitrate of silver, but the sub-acetate of lead (Goulard's extract,) and nitrate of silver, act also on other varieties of animal matter, but muriate of mercury does not. Corrosive sublimate, likewise, may be made a test for detecting salts with a base of ammonia, when applied in the manner to be stated presently.

EXPERIMENT LI.

Dissolve one or two grains of sub-carbonate of potash in half a test tube full of distilled water, and add to it a few drops of the solution of the oxy-muriate of mercury; an orange coloured precipitate will immediately fall down to the bottom of the tube.

EXPERIMENT LII.

Add to half a test tube full of distilled water, a grain or two of sub-carbonate of soda, and drop into

the solution oxy-muriate of mercury, and the same effect will take place as in the preceding experiment.

EXPERIMENT LIII.

Dissolve a few grains of caustic potash, or soda, in half a test tube full of water, and drop into the fluid a solution of oxy-muriate of mercury; at first a sulphur yellow precipitate will fall down, but, by increasing the ad-mixture of oxy-muriate, the precipitate will assume a dull orange colour.

EXPERIMENT LIV.

Half fill a test tube with fresh prepared lime-water, and add to it a few drops of the solution of corrosive snblimate: an orange yellow precipitate will instantly fall down.

EXPERIMENT LV.

Mix a small quantity of the albumen or white of an egg with distilled water, and suffer it to stand till the insoluble part has subsided. Decant the clear fluid, and drop into it a solution of corrosive muriate of mercury; a milkiness will ensue, and after some time a white flocculent precipitate becomes deposited.

The same effect takes place, if serum of blood be mixed with water, or any other albuminous matter. A drop of a saturated solution of oxy-muriate of mercury, when added to water containing 1-1,000 part of its weight of albumen, produces a visible cloudiness: and at the end of some hours, a floccu-

lent precipitate falls to the bottom of the vessel. The same re-agent produces a sensible effect on a liquid containing only half that quantity, or 1-2,000 of albumen, if the mixture be suffered to stand for some hours.

This test should be kept in the dark, because light renders it turbid, a white precipitate (sub-muriate of mercury) separates, and its action is impaired.

EXPERIMENT LVI.

Dissolve one grain of muriate of ammonia in a wine glass full of distilled water, and add to the fluid a single drop of a solution of potash or of soda. If now a drop or two of the solution of oxy-muriate of mercury be added, the mixture will become milky, and a white precipitate falls down, consisting of muriatic acid, mercury, and ammonia.

EXPERIMENT LVII.

Add one grain of nitrate of ammonia to a wine glass full of distilled water, and after having added to it also a drop of a solution of any alcali, let fall into the mixture a drop of the solution of corrosive sublimate, or oxy-muriate of mercury; a white precipitate (sub-oxy-muriate of mercury and ammonia,) will instantly fall down.

It is essential that the solution be neutral. The delicacy of oxy-muriate of mercury, when thus applied for detecting ammoniacal salts, is extremely great. One grain of muriate of ammonia dissolved

in 16 ounces of water may be detected by it. For the application of this test we are indebted to Mr. F. Brande.

XVI. SUB-NITRATE OF MERCURY.

Is employed as one of the re-agents for detecting uncombined ammonia, with which it produces an ash-grey, or black precipitate. It may likewise be used for detecting muriatic acid, with which it occasions a white precipitate, one part of muriatic acid combined with 300,000 parts of water may readily be discovered by this re-agent.

It is also an useful test for detecting not only the presence, but likewise the quantity of phosphoric acid contained in any fluid; for it produces with this acid, a white precipitate, which is soluble in an excess of phosphoric acid, and also in nitric acid, which the precipitate produced by muriatic acid is not. The precipitate obtained by phosphoric acid, (phosphate of mercury) may be decomposed, by mere exposure to heat, and thus the phosphoric acid is obtained in a pure state. Or if the precipitate is exposed to the blowpipe heat upon charcoal, it first melts with effervescence and a green flame, into a yellowish glass; by continuing the heat the mercury is volatilised, and may be condensed in its metallic state on a plate of copper held over the vapour; the phosphoric acid then burns off into phosphorus. With a solution of muriate of gold it produces a dense precipitate, of a

bluish black colour; and with muriate of platina an orange coloured precipitate.

Some precautions, however, are necessary, when this test is employed for discovering phosphoric acid: namely, it is essential that the fluid should not contain any free alcali, or alcaline earth. Sub-nitrate of mercury may also be applied for discovering sulphuric acid, with which it affords a white crystaline or pulverulent precipitate, which becomes yellow when repeatedly washed with boiling water.

EXPERIMENT LVIII.

Add to half a test tube full of distilled water a drop of liquid ammonia, no change will take place, but if a few drops of a solution of sub-nitrate of mercury are added, an ash grey precipitate instantly falls down to the bottom of the tube.

EXPERIMENT LIX.

Add to half a wine glass full of distilled water, a drop of muriatic acid, or a single grain of common salt, and pour into the solution a few drops of sub-nitrate of mercury; white clouds will be produced, and a white precipitate fall down to the bottom, which will not disappear, or become re-dissolved, by the admixture of nitric acid.

EXPERIMENT LX.

Dissolve a few grains of phosphate of soda in half a test tube full of distilled water, and add to it a solution of sub-nitrate of mercury; a white precipitate

will fall down (phosphate of mercury). When the precipitate has subsided, decant the supernatant fluid, and assay the precipitate by adding to it nitric acid, which will speedily dissolve it.

EXPERIMENT LXI.

Add to half a test tube full of distilled water three or four drops of sulphuric acid, or dissolve in the water six or nine grains of sulphate of soda, and add to the fluid sub-nitrate of mercury, a dense white precipitate will take place, and speedily settle to the bottom. This precipitate, by the repeated affusion of boiling hot water, acquires a yellow colour.

EXPERIMENT LXII.

Mix with half a test tube full of distilled water a few drops of muriate of gold, and add to the mixture one or two drops of sub-nitrate of mercury; a bluish black precipitate will instantly be formed.

EXPERIMENT LXIII.

Let fall one drop of muriate of platina into half a wine glass full of distilled water, and add to this mixture a drop of sub-nitrate of mercury; a bright orange coloured precipitate will fall down to the bottom of the tube.

XVII. NITRATE OF SILVER.

The solution of silver in nitric acid is an excellent test, for discovering muriatic acid, either in a free state, or when combined with other bodies. It pro-

duces with it a curdy white precipitate, which is insoluble in water, but readily soluble in liquid ammonia, and which becomes speedily blackened on exposure to light.

The delicacy of this test is astonishingly great; one grain of common salt, dissolved in 42,250 grains of water, that is, rather more than five pounds of water, is rendered obvious by it, white clouds being produced in the fluid; and this quantity of water, it may be proved, does not contain more than 1-108,333 part of its weight of real muriatic acid.

In applying this test, certain precautions are necessary, because it is also acted on by alcaline and earthy carbonates, and by sulphuric acid and its combinations. This may be guarded against, by first removing the sulphuric acid, by nitrate of barytes; and the action of the carbonates may be prevented, by supersaturating them previously with pure nitric acid. The precipitate produced by carbonated alcalies, (carbonate of silver,) is soluble in dilute nitric acid with effervescence, the precipitate produced by muriatic acid is not. With the assistance of an alcali, nitrate of silver becomes likewise an excellent test, for detecting minute portions of arsenic, with which it produces a yellow precipitate. It likewise indicates minute portions of sulphuretted hydrogen, and sulphurets in general, for it produces with them a black precipitate. It affords with chromic acid a carmine red precipitate.

EXPERIMENT LXIV.

Mix a drop of muriatic acid with a wine glass full of distilled water; and add to the mixture a drop of the solution of nitrate of silver; a white curdy precipitate (muriate of silver) will immediately be produced and fall rapidly to the bottom of the glass. 100 grains of this precipitate thoroughly dried, but not melted, contain 75,235 grains of silver; the remaining 24,765 grains consist of muriatic acid, and oxigen. It may be reduced in the following manner to the metallic state, and affords the purest silver which can be obtained.

EXPERIMENT LXV.

Mix one part of dry muriate of silver with three of subcarbonate of soda, or potash of commerce, freed from water by heat; put the mixture into the bowl of a tobacco pipe, and make it red hot in a common coal fire. When the mass has been in perfect fusion for about ten minutes suffer it to become cold. On breaking the pipe a brilliant button of pure silver will be found at the bottom of the vessel.

Nitrate of silver is used as a test by the refiners, for examining and purifying their aqua fortis, or nitrous acid. They let fall into the acid of commerce a few drops of a solution of nitrate of silver. If the acid remains clear it is fit for their use; otherwise they add a small quantity more of the solution, which immediately turns the whole of a milky-white co-

lour; the mixture being then suffered to rest for some time, deposits a white sediment (muriate of silver) from which it is cautiously decanted, examined again, and if necessary further purified by a fresh addition of the solution of nitrate of silver.

EXPERIMENT LXVI.

Add a grain or two of common salt to half a test tube full of distilled water; and drop into the solution nitrate of silver; the mixture will instantly become turbid, and a dense white precipitate will fall down to the bottom of the tube. Decant the supernatant fluid, and pour liquid ammonia upon the precipitate, which will immediately produce with it a transparent solution, namely, nitrate of silver and ammonia. This is one of the characters by which muriate of silver is discriminated from muriate of lead; for the latter is not soluble in liquid ammonia.

EXPERIMENT LXVII.

Prepare muriate of silver in the manner stated; namely, by decomposing a solution of common salt in water with nitrate of silver; wash the muriate whilst still wet, with water, dry it on blotting paper, and keep it exposed to the light of day. Its beautiful white colour will speedily be changed, and in a few hours it will have acquired a bluish black colour.

This change of colour is supposed to be owing to the partial reduction of the oxide of silver, from the light expelling a portion of its oxigen. But there is

reason to believe that it originates solely from a partial disengagement of a portion of the acid; because it is produced likewise by heat, for muriate of silver becomes blackened before it enters into fusion, and a small quantity of muriatic acid, without any oxigen, becomes disengaged. It likewise takes place by the action of air, independent of light; for muriate of silver, exposed in an utter dark place to a brisk current of air, becomes blackened; but not so speedily as in the rays of the sun.

EPXERIMENT LXVIII.

When the quantity of muriatic acid in a fluid is extremely small indeed, no actual precipitate can be collected, but the solution which was limped before mixture becomes more or less opalescent afterwards, as may be shown by dropping nitrate of silver into a decanter full of common spring or river water, which will almost immediately become more or less clouded or milky, according to the quantity of muriatic acid which it contains, in some combination or other, but no precipitate can be collected. In the analysis of mineral waters, this test saves much trouble to the operator. If the water, for example, contains only muriate of potash, and of soda, all other ingredients having been previously separated, we have only to decompose them by nitrate of silver, and to dry the precipitate; for 217.65 of muriate of silver indicate 100 of muriate of potash, and 235 of muriate of silver indicate 100 of common salt.

EXPERIMENT LXIX.

Let five or six grains of sulphate of soda, (Glauber's salt), or Epsom salt, or alum, be dissolved in a test tube, full of distilled water, and put half the mixture into another or second tube. Add to the contents of the first tube a few drops of nitrate of silver. A considerable turbidness will take place; because the oxide of silver combines with the sulphuric acid of the sulphate, and forms with it an indissoluble compound salt, (sulphate of silver,) decant the supernatant fluid and transfer the precipitate, which has a pulverulent form, into a basin containing distilled water, which will speedily dissolve it, when assisted by a gentle heat, but which is not the case with muriate of silver; but which is perfectly insoluble in water.

EXPERIMENT LXX.

Add to the other half of the solution of sulphate of soda (Experiment LXIX.) nitrate of barytes, till no further cloudiness takes place, separate the precipitate, which is sulphate of barytes, by throwing the whole on a filtre, and assay or test the fluid, which passes through the filtre, again with nitrate of silver, which now no longer will produce a precipitate, because the sulphuric acid has been removed by the nitrate of barytes.

EXPERIMENT LXXI.

Dissolve a few grains of sub-carbonate of potash, or of soda, in half a wine glass full of distilled water,

and add nitrate of silver to the solution. A white precipitate will fall down, namely, carbonate of silver. But if a little pure nitric acid be added, this precipitate will become re-dissolved with an effervescence, which is not the case with muriate of silver.

EXPERIMENT LXXII.

Again add a few grains of sub-carbonate of potash, or of soda, to half a glass full of distilled water, and drop into it so much nitric acid, as is sufficient to neutralize the subcarbonate of potash, which may be known by the solution not changing turmeric paper brown. (See page 35.) If into this fluid nitrate of silver be dropped, it will not become turbid, and the effect of the carbonated alcali is thus counteracted by nitric acid. If a grain of common salt or any other combination of muriatic acid be added to the fluid, the nitrate of silver will immediately indicate the presence of muriatic acid, by a copious white curdy or flocculent precipitate.

EXPERIMENT LXXIII.

The power of nitrate of silver is so great, that it will discover the minute quantity of muriate of soda which constantly adheres to the skin, and is deposited there, from the perspirable matter of the living body. To show this fact, put some distilled water with a few drops of nitrate of silver into a test tube, and shake it, closing the tube with the finger on the open end, appliedas a stopper. The mixture, after a few

minutes shaking, will become perceptibly turbid, on account of having removed from the cuticle of the finger so minute a portion of muriate of soda, as defies the imagination, but the presence of which is thus rendered by the test obvious to the senses.

For the application of nitrate of silver as a test to detect minute portions of arsenic, we are indebted to Mr. Hume, according to whose directions it is to be used in the solid state, or as fused sub-nitrate of silver, vulgarly called *lunar caustic*. The following process will illustrate its action.

EXPERIMENT LXXIV.

Put two or three grains of arsenious acid, (white arsenic) and eight ounces of rain or distilled water, into a florence flask, heat the mixture over the lamp till the solution boils, and then add to it a grain or two of sub-carbonate of potash or of soda. Pour a few table spoons full of the solution into a wine glass, and present to the mere surface of the liquid a stick of dry sub-nitrate of silver. A yellow precipitate will instantly appear, which will proceed from the point of contact of the sub-nitrate with the fluid, and settle towards the bottom of the glass as a flocculent and copious precipitate. Dr. Marcet has lately pointed out the following modification of this test.

EXPERIMENT LXXV.

Let the fluid suspected to contain arsenic be filtered, and suffer the end of a glass rod, wetted with liquid

ammonia to be brought into contact with it, and let the end of a glass rod, also wetted with the solution of nitrate of silver, be immersed in the mixture, a yellow precipitate will appear at the point of contact, and will gradually fall down to the bottom. As this precipitate is soluble in ammonia, the greatest care is necessary not to add an excess of that alcali.

The objection arising from the action of muriatic acid upon this test, when thus employed for arsenic, is easily obviated; for if a little muriatic acid be added to the fluid suspected to contain arsenic, and the nitrate of silver be very cautiously added, till the precipitate ceases, the muriatic acid will be removed, and the arsenic remain in solution. The addition of liquid ammonia will produce the yellow precipitate in its characteristic form.

EXPERIMENT LXXVI.

The effect of nitrate of silver, for detecting minute portions of sulphuretted hydrogen, may be shown, by immersing part of the white of an egg coagulated by heat into distilled water mixed with a small quantity of nitrate of silver, and suffering it to stand for about 24 hours. During this time the whole solution, as well as the albumen, will acquire a dark brown colour, because the albumen of the egg contains sulphur. The blackening of a silver spoon, on touching it with the white of a boiled egg, also illustrates this fact.

EXPERIMENT LXXVII.

Put water impregnated with sulphuretted hydrogen gas into a saucer or wine glass, and hold over, and also close to the surface of the water, a slip of paper wetted with a solution of nitrate of silver. The sulphuretted hydrogen gas, escaping from the fluid, will instantly cause the solution of silver to become blackened; the silver which it contains will re-appear in a metallic form, and being combined with sulphur, the whole assumes a brilliant metallic and iridescent colour.

EXPERIMENT LXXVIII.

Write on paper with a dilute solution of nitrate of silver; the writing will be invisible when dry, and kept defended from the light. But if the paper be immersed into water impregnated with sulphuretted hydrogen gas; or if a feather or sponge dipped in this fluid be passed over it; the characters will instantly acquire a dark brown colour, the intensity of which is according to the strength of the nitrate of silver employed.

XVIII. ACETATE OF SILVER.

This re-agent, the chemical action of which is in every respect similar to nitrate of silver, is particularly well adapted for examining mixtures of nitrates and muriates, if we wish to ascertain and separate the muriatic acid, without adding any additional quantity or extraneous nitric acid to the mixture,

which would be the case if nitrate of silver be employed. We become thus also enabled to discriminate the alcali combined with the muriatic acid more readily by its appropriate tests, namely, muriate of platina, &c. Or even without the usual tests for alcalies; namely, by simply evaporating to dryness the fluid from which the muriatic acid has been separated by means of the acetate of silver, and redissolving the dry mass in alcohol. If this solution, after being evaporated to dryness, affords a deliquescent salt, we have reason to believe that the base of the salt is potash; and if it effloresces, and remains dry on exposure to the air, there is then reason to believe it to be soda; or, for example, when nitrate of potash accompanies sulphates and muriates without any other nitrate, the sulphates being decomposed by acetate of barytes, and the muriates by acetate of silver. The fluid after filtration may be evaporated to dryness, and the residuum treated with alcohol, which dissolves the acetates and leaves the nitrate; the quantity of which may be easily estimated. If an alcali be present, it ought, of course, to be previously saturated with an acid. Acetate of silver is decomposed by exposure to light. The bottle containing a solution of it becomes covered within with a metallic coat of silver, and a black powder separates. It therefore must be kept in opake bottles, or in the dark.

XIX. SULPHATE OF SILVER.

The combination of silver with sulphuric acid may occasionally be used, with advantage, as a test for detecting muriatic acid, where nitrate of silver is not so applicable; because it is not affected, like nitrate of silver, by salts with a base of sulphuric acid, so that when sulphate of silver is employed, we are certain that the precipitate produced by this test, when no uncombined alcali or earth is in the solution, is produced by muriatic acid only.

This test is best kept in opake bottles, for light has an action upon it. The silver which it contains is in part reduced, and falls down as a black powder.

XX. PHOSPHATE OF SODA.

This salt, in combination with carbonate of ammonia, is employed as a re-agent for separating magnesia. The process was first pointed out by Wollaston, and is as follows. Pour a solution of neutral carbonate of ammonia into the fluid suspected to contain magnesia. No magnesia becomes precipitated if this earth be present, because the carbonic acid of the carbonate of ammonia is sufficient to keep it in solution. But on adding phosphate of soda, the magnesia is transferred to the phosphoric acid, and with which, and the ammonia, it falls down, as an insoluble triple salt. It is essential that the solutions should be somewhat concentrated; and that the carbonate of ammonia be neutral. Phosphate of soda, when deprived of its water of crystallization, is

likewise employed as a flux for the blowpipe ; it materially facilitates the fusion of earthy substances and metallic oxides, and forms a more manageable flux than phosphate of soda and ammonia, which is frequently recommended for similar purposes.

EXPERIMENT LXXIX.

Add to a solution of sulphate of magnesia a solution of carbonate of ammonia, in sufficient quantity to saturate the acid, no change will take place ; but if to this fluid, which now contains sulphate of ammonia and carbonate of magnesia, a cold and saturated solution of phosphate of soda be added, it immediately becomes turbid, and a white powder subsides, which is a triple salt ; namely, phosphate of magnesia and ammonia.

100 grains of this salt, dried at a temperature of 100°, contain 19 of magnesia ; about 16 of muriate of magnesia ; and 62 of desiccated, or double that quantity of crystallized, sulphate of magnesia. If instead of drying the precipitate at a gentle heat, we calcine it, we may then reckon the calcined phosphate of magnesia to indicate, in every 100 grains, 38,5 of magnesia, or to be equivalent to 226 grains of the crystallized sulphate of that earth.

EXPERIMENT LXXX.

Dissolve common magnesia of commerce (subcarbonate of magnesia) in muriatic acid, and add to the solution, carbonate of ammonia, no change will take

place ; but if a strong solution of phosphate of soda be added to the fluid which contains the muriate of magnesia and carbonate of ammonia, the mixture becomes turbid, and phosphate of magnesia and ammonia is deposited.

XXI. LIME WATER.

This fluid is frequently employed for ascertaining the presence of carbonic acid, not combined with a base, or combined in excess, with which it produces a white pulverulent precipitate, which again disappears, when an excess of the fluid containing the carbonic acid is added (page 92); because the excess of the carbonic acid re-dissolves the neutral carbonate, which produced the cloudiness. The transparency of the mixture is likewise restored by muriatic or nitric acid. The action of lime water is therefore modified, according to the quantity of the substance upon which it is made to act. There is another object which requires to be considered with regard to this test, to avoid fallacious results; namely, the precipitation of salts with a base of magnesia or alumine, which, with lime water, also produce a white precipitate. And a cloudiness is further produced, when sulphates are made to act upon this test. But the precipitate occasioned by lime may readily be discriminated, as will be stated presently. Lime-water is farther made use of, as a test for oxy-muriate of mercury, or corrosive sublimate, with which it produces, according to the quantity added, either a

yellow or a brick-dust coloured precipitate; and occasionally also for detecting the presence of arsenic, with the solutions of which it forms a white precipitate (arseniate of lime) which, being scarcely more soluble then sulphate of lime, sinks to the bottom in the form of minute crystals, and when laid on an ignited piece of charcoal diffues the alliaceous odour peculiar to arsenic.

Some chemists have endeavoured to estimate the quantity of carbonic acid when contained in a mineral water, by the admixture of lime-water; namely, by adding lime-water to the mineral-water, fresh from the fountain head, and collecting, drying, and weighing the carbonate of lime thus produced. But this method is fallacious in most cases, for the lime-water also precipitates all the carbonate of lime held in solution by carbonic acid, and the carbonate of magnesia, and besides it decomposes other magnesian salts, and causes their earth to precipitate.

EXPERIMENT LXXXI.

Half fill a wine glass with fresh prepared lime-water, and blow through the water by means of a tobacco pipe, or quill, the air respired from the lungs. The lime-water will by this operation be rendered turbid, because the carbonic acid gas expired from the lungs combines with the dissolved lime, and forms with it a neutral carbonate of lime, which, being insoluble in water, becomes precipitated. The precipitate may be made to disappear by the admixture of muriatic or nitric acid.

EXPERIMENT LXXXII.

Half fill a test tube with water impregnated with carbonic acid gas, and add to it lime-water, a white precipitate (carbonate of lime) will fall down, which again becomes dissolved by the admixture of a few drops of muriatic or nitric acid.

EXPERIMENT LXXXIII.

Fill a two ounce phial with carbonic acid gas (for the method of obtaining this gazeous fluid, see index, carbonic acid) and add to it about a table spoonfull of lime-water, close the phial and shake it; the lime-water will become milky, because a neutral carbonate of lime is produced. Put the turbid mixture aside, and again fill the phial with carbonic acid gas, and pour this mixture again into the phial filled a second time with the gas. The lime-water will now become perfectly transparent, or if not, expose it for a third time to a fresh portion of carbonic acid gas. The transparency thus effected is owing to the neutral carbonate of lime having combined with an additional quantity or excess of carbonic acid gas: a new body or super-carbonate of lime being produced, which is soluble in water. We therefore see, that if water holding carbonic acid gas in solution be added, in small quantity only, to lime-water, an instant milkiness ensues, and a precipitate of carbonate of lime is produced; but if an excess of the carbonated water be added, it becomes clear again. If the fluid be heated, or merely suffered to be exposed to the open

air, the excess of carbonic acid gas flies off, and a neutral carbonate of lime is re-produced, which being insoluble falls down as a white precipitate.

Hence all pump or well waters holding in solution super-carbonate of lime &c. become turbid by boiling, and a crust or *fur*, as it is called, is deposited in tea kettles, and other vessels, in which such waters are frequently boiled; the heat expels the excess of carbonic acid which held the earthy carbonate in solution, and the neutral carbonate of lime is deposited. It is thus that nature dissolves calcareous masses, which have been collected and deposited by these waters. When the waters, by their exposure to the air, lose the quantity of carbonic acid which favoured the solution of the lime, deposits are formed, and thus originate calcareous incrustations found in caverns, springs, &c. When these waters suddenly lose the excess of carbonic acid which was essential to the solution of the lime, there is an irregular precipitation; hence those tender calcareous cellular stones and calcareous spongy *tuffs:* but if the evaporation of the carbonic acid takes place slowly, it produces crystallizations, such as *stalactites*, &c.

EXPERIMENT LXXXIV.

To a few ounces of fresh prepared lime water add two or three grains of subcarbonate of potash, the solution will become turbid, and yield a white precipitate; because the carbonic acid of the alcaline subcarbonate unites with the lime, and forms, with it,

a subcarbonate of lime, which being insoluble falls to the bottom; add dilute muriatic or nitric acid, and the precipitate will again become dissolved.

EXPERIMENT LXXXV.

Dissolve five or six grains of sulphate of magnesia, (Epsom salt) in half a wine glass full of distilled water, and pour a little fresh prepared lime water into the solution; it will become turbid, and a white pulverulent precipitate will gradually fall down to the bottom of the glass. Lime water therefore decomposes also the salts of magnesia.

EXPERIMENT LXXXVI.

Mix five or six drops of a concentrated solution of corrosive sublimate with half a test tube full of lime water, no brick dust or orange coloured precipitate will be produced, but a yellow precipitate will fall down: on adding gradually more of the solution of corrosive sublimate, the mixture will acquire an orange colour, and a precipitate of the same hue will be deposited.

EXPERIMENT LXXXVII.

Let fall eight or ten drops of a solution of arsenious acid into a wine glass containing about one table spoonful of distilled water; and fill the remainder of the glass with fresh prepared lime water. The mixture will become milky in a few minutes, and a white flocculent precipitate (arsenite of lime) will gradually collect at the bottom of the glass. If to the tur-

bid liquid, thus obtained, a few drops of acetic or nitric acid be added, it will become clear again, because the precipitate becomes completely redissolved; and the result takes place, by a copious admixture of the solution of arsenious acid. If the precipitate (arsenite of lime) be dried, and placed on an ignited piece of charcoal, it yields an alliaceous odour, which is peculiar to arsenic.

Lime water does not keep, but is speedily rendered useless, on account of the carbonic acid gas which it attracts from the air, when the bottle containing it is frequently opened. It may be readily prepared for immediate use in the following manner.

Take two ounces of fresh burnt quicklime, put it into a stone-ware vessel, and gradually sprinkle on it so much distilled or rain water, as is sufficient to slake the lime, and keep the vessel covered whilst the lime slakes and falls into powder. This being done, pour on it a pint of distilled or rain water, and mix the lime thoroughly with the water by stirring. After the lime has subsided, repeat the stirring and agitation for several times successively during the space of 24 hours, and then preserve the liquor, upon a part of the lime left undissolved, in a well corked bottle, and filter or decant off the lime water, when wanted for use.

The proportion of water above stated to be used is scarcely sufficient to dissolve one-tenth part of the lime; but lime being of little value, and seldom thoroughly good, a little waste of this material is of no

importance, where the object is to obtain a saturated solution of it in water quickly and easily.

The most convenient state for keeping lime fit for immediate use is to convert it into a *hydrate*, which may be done by sprinkling so much water on dry quicklime, as is just sufficient to cause the lime to fall into a perfectly dry powder. In this compound, or *hydrate of lime*, the lime is to the water as 23 to 8. It may safely be preserved in this state in glass bottles; which cannot be done with quicklime in its perfect dry form, for in that state it almost constantly breaks the bottle, on account of its swelling, from the moisture which it attracts when the bottle is occasionally opened.

XXII. TAN.

This substance is employed for detecting animal gelatine, or jelly, with which it forms an elastic, adhesive mass, which soon dries in the open air, and becomes converted into a brittle resinous-like substance, which is insoluble in water, and capable of resisting a great number of chemical agents. It greatly resembles over-tanned leather. The power of tan as a test of gelatine is very great. Dr. Bostock found a copious and *immediate* precipitate, on adding a moderately strong infusion of tan to water containing only 1-1000 of isinglass, and a very considerable precipitate when the gelatine was only 1-2000. An *immediate* precipitate with tan may therefore be considered as a pretty certain indication of gelatine.

To render this test accurate, it is necessary to attend to the circumstance, that tan likewise produces a precipitate with albumen. This, however, is much less evident; it does not take place *immediately*, but only after the mixture has stood for some time; and the distinction between these bodies is likewise easily established by the use of other tests.

Dr. Bostock has also pointed out a very ingenious method of detecting and ascertaining the quantity of gelatine contained in an animal fluid. If oxy-muriate of mercury produces no precipitate (see oxy-muriate of mercury, p. 73) we may be certain of the absence of albumen. Then the infusion of tan being mixed with the liquid in such a proportion that the filtered fluid will neither precipitate infusion of tan, or the animal liquid under examination, a precipitate falls down, composed of about two parts of tan and three parts gelatine. Hence this precipitate dried in a steam bath, and multiplied by 0.6 gives the weight of gelatine in the liquid examined, very nearly.

EXPERIMENT LXXXVIII.

Mix a small quantity of dissolved glue, or isinglass, with water, and drop into it a solution of tan; a copious flocculent precipitate will immediately fall down, consisting of tan and gelatine.

EXPERIMENT LXXXIX.

Dissolve a small quantity of portable soup, (which may be had at the confectioners') in boiling water,

and add to it a solution of tan; an abundant curdy precipitate will take place, as in the preceding experiment. The same will be the case if tan be dropped into broth.

XXIII. NITRATE OF COBALT.

This salt has of late been recommended, by Mr. Gahn, the celebrated German mineralogist, and discoverer of the metallic nature of manganese, as a test for readily discovering the presence of alumine in mineral substances, when submitted to the trial of the blowpipe assay. It is to be used in the following manner; put on the substance to be tried a drop, or less, of a concentrated solution of nitrate of cobalt, and then expose it to the flame of the blowpipe dart. If the mineral contains alumine, in any notable quantity, and is not too much charged with iron, or other colouring metals, it will soon acquire a blue colour, more or less vivid and intense, according to the purity and abundance of the alumine which it contains.

The test may be applied to the hardest gems, or softest clays. When the mineral is a hard stone, it is only necessary to pulverise it well, and to drop on it a minute portion of the test, and then to expose it to the action of the blowpipe dart, upon a piece of platina foil. The test, however, labours under one disadvantage, for the earth of zircon produces the same blue colour: but as the characters of zircon earth are exceedingly well marked, the application of a few additional tests readily enables us to know to which of the earths the colour be owing.

EXPERIMENT XC.

Let fall a drop of a solution of nitrate of cobalt upon a piece of common pipe-clay of the size of a pea, and heat the mixture gradually, on a slip of platina foil, before the blowpipe flame; the clay will acquire a smalt blue colour.

EXPERIMENT XCI.

Moisten a piece of quicklime, chalk, magnesia, or a minute portion of pulverised flint, with nitrate of cobalt, and expose the mixture to the heat of the blowpipe dart; these earths will not acquire a blue colour; the mere effect of the nitrate of cobalt will be, to impart to them, before the blowpipe flame, a dull gray or black colour.

EXPERIMENT XCII.

Again; take a piece of light yellow ochre, drop on it a minute quantity of nitrate of cobalt, and make it red hot by means of the blowpipe flame; this substance will acquire a dark blue or purple colour; because ochre is chiefly composed of alumine. The oxide of iron which it contains acquires a red colour when heated, and this, with the blue effected by alumine, produces the purple or violet tinge.

XXIV. SUPER-ACETATE OF LEAD.

This is another test which may be employed for detecting muriatic acid and sulphuric acid, with both of which it occasions a white precipitate, namely

muriate of lead, and sulphate of lead. The precipitate produced by muriatic acid is soluble in dilute nitric and acetic acid, (see page 61 and 63) but the precipitate produced by sulphuric acid is not. Its action upon muriatic acid is much inferior to nitrate of silver. It is also decomposed by alcalies and earthy carbonates; but this may be prevented by a previous admixture of nitric acid. Super-acetate of lead, (or more properly acetate of lead) may also be employed as a test for phosphoric acid, with which it produces a white precipitate; even a solution of phosphate of lime is completely decomposed by this salt, all the phosphoric acid is separated, and by double decomposition a precipitate of phosphate of lead is produced, which is readily known by the following characters. When heated by the blowpipe on a piece of charcoal, it melts easily into a pearl-white globule, which immediately on discontinuing the flame cools into a button of a polyhedral form; and if the flame be continued, the phosphoric acid is gradually decomposed, and burns off with a luminous vapour smelling of phosphorus, and at last a globule of pure lead is left. The precipitate or phosphate of lead, when dried at a low red heat, contains 22.5 per cent. of phosphoric acid. If sulphuric acid in any combination should happen to be present in the solution of phosphate of lime, it will also be decomposed by the super-acetate of lead, and the precipitate will therefore be a mixture of sulphate and phosphate of lead. These are separable by dilute nitric acid, which will

dissolve the phosphate of lead, but not the sulphate. Super-acetate of lead is one of the most delicate tests for discovering minute portions of sulphuretted hydrogen gas, or sulphurets in general, with which it instantly forms a black precipitate. It has been recommended as a test for carbonic acid, but is seldom employed for that purpose, for we have better tests for carbonic acids. It has also been used as a test for uncombined boracic acid, particularly in the analysis of mineral waters. In that case the uncombined alcalies and earths (if any be present) must be saturated with acetic acid. The sulphates, if any are present, must be decomposed by acetate or nitrate of barytes, and the muriates by acetate or nitrate of silver. The filtered liquor, if boracic acid be contained in the water, will continue to give a precipitate, which is soluble in nitric acid of the specific gravity 1.3, and this precipitate or borate of lead may be decomposed by boiling with sulphuric acid; which forms with it sulphate of lead, and the boracic acid is set at liberty. The fluid containing the boracic acid may then be evaporated to dryness, and digested in alcohol, which then takes up the boracic acid.

EXPERIMENT XCIII.

Drop into a test tube, half filled with distilled water, a grain of common salt, or a drop of muriatic acid, and add to the solution a drop of super-acetate of lead; a white precipitate will immediately fall down, which is muriate of lead. This precipitate is

again soluble with the assistance of heat in nitric or acetic acid, and also in a large quantity of boiling water (see page 62,) 100 parts of the dried precipitate indicate 75 of metallic lead.

EXPERIMENT XCIV.

Add to half a test tube full of distilled water a grain or two, of sulphate of soda, or of sulphate of potash, and assay it by the admixture of super-acetate of lead; an abundant white precipitate will fall down, which is sulphate of lead.

EXPERIMENT XCV.

Repeat the same experiment with a single drop of sulphuric acid, added to a wine glass full of water; and the same appearance as in experiment XCIV. will take place; 100 parts of the precipitate (sulphate of lead) after having been heated moderately to redness, indicate 71 of lead.

EXPERIMENT XCVI.

Super-acetate of lead is the test usually employed in commerce for detecting the genuineness of lemon juice. This article, which is largely imported in the liquid state, is not unfrequently adulterated with some strong and cheaper acid. The sulphuric acid is most to be suspected. It is detected in the following way; put some of the juice in a glass, and add to it a solution of super-acetate of lead. This will produce a copious white sediment; after which add a few drops of

strong nitric acid. If the juice contained no sulphuric acid, the white precipitate will be re-dissolved, and the liquor become again clear, the citrate of lead, (and malate of lead of which a small portion will also be formed) being readily soluble in nitric acid, but if the lemon juice was mixed with sulphuric acid, the sulphate of lead will remain at the bottom. If this be collected, washed, and dried, the quantity of sulphuric acid may be estimated from the known proportions of this salt, as stated, page 102.

EXPERIMENT XCVII.

Dissolve a few grains of sub-carbonate of soda, or of potash, in a wine glass full of distilled water, and pour half the solution into another glass. Drop into one of the glasses a little super-acetate of lead; a white precipitate (carbonate of lead) will immediately be formed. Add to the other glass nitric acid, till the potash contained in the fluid is neutralized. This being done, pour into it also a few drops of super-acetate of lead, no precipitate will now appear, because the action of the sub-carbonated alcali is thus counteracted, and the test will now indicate muriatic and sulphuric acid.

EXPERIMENT XCVIII.

Add to any quantity of water impregnated with sulphuretted hydrogen gas a drop of super-acetate of lead; clouds of a dark brown colour will immediately appear, and a precipitate of the same colour will be deposited, which is hydro-sulphuret of lead.

EXPERIMENT XCIX.

The effect of a sympathetic ink, with super-acetate of lead, may serve to show in a striking manner the action of this test, with regard to sulphuretted hydrogen; namely, by writing on paper with a pen dipped into super-acetate of lead. No characters will be visible (if the writing has been made with a dilute solution of the re-agent.) And if the paper be held over a saucer, or other vessel, containing water impregnated with sulphuretted hydrogen gas, or when the paper is moistened with this liquid, the letters assume a brilliant metallic and irridescent colour.

EXPERIMENT C.

Dissolve two grains of phosphate of soda in half a test tube full of distilled water, and drop into the solution a little super-acetate of lead; a white precipitate will take place, which is phosphate of lead. —This precipitate disappears again by the admixture of nitric acid.

EXPERIMENT CI.

Affuse upon bone ash (bone burnt to whiteness) sulphuric acid; a partial decomposition will take place, because bone, which is phosphate of lime, gives up part of its lime to the sulphuric acid, and an acidulous phosphate of lime is produced. If into this fluid, when diluted with water, a few drops of super-acetate of lead are suffered to fall, a white pre-

cipitate takes place, which consists of all the phosphoric acid united to oxide of lead. The sulphuric acid also falls down, in combination with another portion of the oxide of lead, and forms sulphate of lead. These two precipitates may be separated by dilute nitric acid, which dissolves the phosphate, but does not touch the sulphate of lead.

EXPERIMENT CII.

Let fall into water impregnated with carbonic acid gas, two or three drops of super-acetate of lead; a white powder will fall down, which is carbonate of lead, (white lead of commerce.) The same effect will take place, if the air respired from the lungs be blown by means of a quill, or glass tube, through a solution of super-acetate of lead. The carbonate of lead is soluble in caustic potash; and by the action of the blow pipe on charcoal the acid is driven off, and the lead is reduced to the metallic state.

Super-acetate of lead strongly attracts carbonic acid from the air, it ought therefore be kept in a well stopped bottle.

XXV. SUB-ACETATE OF LEAD.

This combination of lead with acetic acid, which is vulgarly called *Goulard's Extract*, is recommended by Dr. Bostock to discover the presence of *mucous*, or animal mucilage; and to discriminate it in the analysis of animal fluids from gelatine, with which it has been so often confounded. Sub-acetate of

lead instantly acts upon animal mucous, and produces with it a copious white and flaky precipitate, but it is not sensibly rendered turbid by a solution of animal gelatine. A solution of sub-acetate of lead may also be employed for separating the extractive, acid and colouring matter from wine, so as to enable us to abstract from the remaining colourless liquor, by means of a sub-carbonated alcali, all the water which it contains; and to ascertain in a ready manner the quantity of alcohol or brandy which was present in the wine. And this method of obtaining alcohol or brandy from wine at once destroys the commonly received opinion, first entertained by Fabrony, namely, that the spirit obtained from wine is formed during the distillatory process, whilst on the contrary it clearly proves, that brandy or spirit of wine exists ready formed in all vinous liquors, and that it may be separated from them without distillation. And further: that the quantity thus separated is precisely equal to the proportion yielded by the common method of distillation. The process, which is as follows, was first pointed out by Mr. Brande.

EXPERIMENT CIII.

Add to eight parts by measure of the wine to be examined one part of a concentrated solution of sub-acetate of lead; a dense insoluble precipitate will ensue; it is a combination of the test with the colouring, extractive, and acid matter of the wine.

Shake the mixture for a few minutes, pour the whole upon a filtre, and collect a filtered fluid. It contains the brandy or spirit, and water of the wine, together with a portion of the sub-acetate of lead, provided the latter has not been added in excess; in which case a part (of course) remains undecomposed. Add, in small quantities at a time, to this fluid, warm, dry, and *pure* sub-carbonate of potash, (*not salt of tartar, or sub-carbonate of potash of commerce*) which previously has been freed from water by heat, till the last portion added remains undissolved. The brandy or spirit, contained in the fluid, will thus become separated; for the sub-carbonate of potash abstracts from it the whole of the water with which it was combined; the brandy or spirit of wine forming a distinct stratum, which floats upon the aqueous solution of the alcaline salt. If the experiment be made in a glass tube, from one half an inch to two inches in diameter, and graduated into 100 equal parts; the per centage of spirit in a given quantity of wine may be read off by mere inspection.

By operating on artificial mixtures of alcohol and water, Mr. Brande found, that when the alcohol is not less than 16 per cent. the quantity indicated by the dry and warm sub-carbonate of potash, after the colouring and acid matter has been separated by sub-acetate of lead, was always within one-half part in 100 of the real proportion contained in the mixture.

Table exhibiting a comparative view of the quantity of Alcohol, (specific gravity, 825,) obtained by Mr. Brande from various Wines and Spirituous Liquors.

	Strongest.	Medium.	Weakest.
Rum		53.68	
Brandy		53.39	
Hollands		51.60	
Raisin wine . .		25.77	21.40
Port	25.83	23.49	19.34
Madeira	24.42	22.27	17.26
Marsala	25.87	21.56	
Currant wine .		20.55	
Constantia . . .		19.75	
Sherry	19.83	19.17	18.25
Lisbon		18.94	
Bucellas		18.49	
Red Madeira .		18.40	
Cape muscat . .		18.25	
—— madeira .		18.11	
Grape wine . . .		18.11	
Calcavella		18.10	
White hermitage		17.43	
Rousillon		17.26	
Malaga		17.26	
Malmsey mad.		16.40	
Sheruatz		15.52	
Syracuse		15.28	
Nice		14.63	
Claret	16.32	14.44	12.91
Tent		13.30	
Burgundy	14.53	13.24	11.95
White champ.		12.80	
Vin de Grave .		12.80	
Frontignac . . .		12.79	

Table exhibiting a comparative view of the quantity of Alcohol, (specific gravity, 825,) obtained by Mr. Brande from various Wines and Spirituous Liquors.

	Strongest.	Medium.	Weakest.
Cote roi		12.32	
Red hermitage		12.32	
Gooseberry wine		11.84	
Hock	14.37	11.62	8.88
Tockay		9.88	
Elder wine . . .		9.87	
Cyder		9.87	
Perry		9.87	
Ale		8.88	
Brown stout . .		8.80	

The following Table exhibits the quantity of Alcohol contained in Ale, Porter, and other Kinds of Malt Liquors. See Repository of Arts, No. 2, p. 74, 1816.

Kind of Malt Liquor 100 parts contained.	Quantity of Alcohol. Parts of Alcohol.
Ale, home brewed - - - -	8.30
Ale, Burton, three samples yielded upon an average - - - - -	6.25
Ale, common London-brewed, six samples yielded upon an average - - -	5.
Ale, Scotch, two samples, ditto - -	5.75
Porter, London, eight samples, ditto -	4.
Porter, bottled, three samples, ditto -	2.75
Brown stout, four samples, ditto -	5.
Small Beer, six samples, ditto - -	0.75

EXPERIMENT CIV.

The action of sub-acetate of lead as a test for mucous may be shewn in the following manner. Rince and macerate an oyster in cold distilled water; evaporate to dryness the mucous matter thus obtained; re-dissolve the dry mass in distilled water and filter it. If to this fluid a few drops of sub-acetate of lead be added, a copious white flocculent precipitate will be obtained.

The same effect is produced if the solid matter obtained by evaporating saliva to dryness be re-dissolved in water, filtered and submitted to the action of this test.

XXVI. MURIATE OF PLATINA.

This is a valuable test for distinguishing the salts of potash from those of soda, it produces with all the salts of potash, a yellow precipitate, which is not an oxide of platina, but a triple salt, (prussiate of platina and potash) and it does not affect the salts with a base of soda. In using this test, it is essential that there be no excess of acid; and the solution should be somewhat concentrated. Its action is greater than tartareous acid, (see page 63.)

EXPERIMENT CV.

Add to half a test tube full of distilled water, a few grains of potash, or sub-carbonate of potash; and then add a drop of the solution of muriate of platina; the fluid will instantly become turbid, and a yellow precipitate will fall to the bottom of the tube.

EXPERIMENT CVI.

Add to a like quantity of distilled water a few grains of soda, or of sub-carbonate of soda, and add to it also muriate of platina; no change will take place, because soda is not precipitable by this test.

EXPERIMENT CVII.

Drop into a concentrated solution of sulphate of potash, a little muriate of platina, the same phenomena will take place as in Experiment CVII.

EXPERIMENT CVIII.

Add to a solution of sulphate of soda, a few drops of muriate of platina, no change will take place.

In this manner the two alcalies, viz. potash and soda, and their combinations, are easily discriminated. *See also Tartareous acid, page* 63.

XXVII. GREEN SULPHATE OF IRON.

This salt has been recommended for ascertaining the presence of oxigen gas, of which mineral, and other waters, sometimes contain a small quantity. The presence of this gas is discovered by dissolving in the water a small quantity of this salt. If the water be entirely free of oxigen, and the phial containing it be well stopt, the solution is transparent; but if otherwise, it soon becomes slightly turbid, from the oxide of iron attracting the oxigen of the water, and a small portion of it in this more highly oxidated state, leaving the acid, becomes precipitated.

Green sulphate of iron is also employed for detecting the presence of gold, with which, when in a state of solution it produces a brown precipitate, which is metallic gold, (see page 70.) It also throws down palladium in a metallic form. It is likewise useful for detecting gallic acid, with which, (like all other salts of iron) it produces a precipitate, which speedily becomes black on exposure to the air.

EXPERIMENT CIX.

Fill a phial brim full with the water to be examined, and drop into it a few crystals of sulphate of iron, and cork the bottle close. In a little time the sulphate of iron will be dissolved, and if the mixture be suffered to stand for six or eight hours, a brown oxide of iron, or ochry precipitate, will fall to the bottom, if oxigen gas was present in the water.

The action of this test must be received with some limitation; for common air, which is present in all natural waters, produces in part a like effect, and it is only from comparing the quantity of the precipitate with common spring water, that some notion may be formed. Mr. Henry expelled the air from a portion of spring water by boiling; 100 cubic inches of the water yielded 4.76 inches of gas. This gas he found a mixture of 3.38 inches of carbonic acid, and 1.38 of atmospherical air. It is to the presence of these two elastic fluids, that water owes its taste, and many of the good effects which it produces on animals and vegetables. Hence the vapidness of

newly boiled water, from which these gases are expelled.

EXPERIMENT CX.

Add to half a test tube full of distilled water a few drops of muriate of gold; no change will take place; but if sulphate of iron dissolved in water be added, a brown precipitate will fall down, which is gold in a metallic state, (see page 71.) This process has been recommended for obtaining pure gold. From the purplish colour which the precipitate possesses, there is however reason to believe that it contains a portion of oxide, and, according to Proust, both muriatic and nitric acid dissolve a little of it, which must be regarded as a proof of this oxidized state.

XXVIII. ARSENIOUS ACID.

A solution of arsenious acid in water is of use for discovering the presence of sulphuretted hydrogen gas, and sulphurets in general, with which it produces a yellow precipitate; and with the salts of lead it produces a white precipitate. It is occasionally used as a standard of comparison, to confirm or invalidate the action of other tests, when employed for the discovery of arsenic, particularly in cases where collateral circumstances render the phenomena of the usual tests doubtful.

EXPERIMENT CXI.

Add a little of the solution of arsenious acid to half a test tube full of distilled water, and no alteration of colour will take place; but on adding to the fluid, water impregnated with sulphuretted hydrogen gas, a bright yellow precipitate will be produced, which is hydro-sulphuret of arsenic.

XXIX. MURIATE OF GOLD.

It is chiefly of use for detecting the presence of tin, with the solutions of which, when the tin is at a *minimum* of oxidation, it produces a purple, or purplish brown precipitate; hence muriate of gold, and sub-muriate of tin, are reciprocally tests for each other. *See sub-muriate of tin.* Muriate of gold has also been recommended as a test for albumen; it throws down a dense flocculent precipitate from a solution containing 1-1,000 part of this substance; but oxy-muriate of mercury (see page 71) is a better test for detecting this substance, because it effects no change in solutions containing jelly, or animal gelatine, and mucous, whereas muriate of gold appears to have a slight action on these bodies.

XXX. SULPHATE OF COPPER.

This salt may be employed for discovering arsenic, with which it produces a bright yellowish green precipitate, provided a very small quantity of a subcarbonated alcali has previously been added to the fluid in which the arsenic is suspected. Water im-

pregnated with sulphuretted hydrogen gas produces, with this salt, a dark brown precipitate, which is a hydro-sulphuret of copper.

EXPERIMENT CXII.

Add a small quantity of solution of arsenious acid to half a wine glass full of distilled water, in which previously a grain of sub-carbonate of potash has been dissolved; a green flocculent precipitate will instantly fall down. This substance, after being dried and mixed with a little powdered charcoal, and put into a glass tube closed at the bottom, and lightly stopped at the top, and then heated slowly to redness, will yield a metallic sublimate, which will give the strong smell peculiar to arsenic, and which condenses on the sides of the tube, and lines it with a brilliant metallic coating. The same strong smell and dense white fumes will be given, merely by putting the dried precipitate on an ignited piece of charcoal.

To identify arsenic, when this is one of the tests employed for detecting it, Dr. Henry advises (very properly) to perform, at the time of making the experiment, similar comparative experiments, with what is actually known to be arsenic.

Because the proportions of sulphate of copper and alcali employed have considerable influence on the distinct exhibition of the effect. Those which answer best are, one of arsenic, three of sub-carbonate of potash (or common salt of tartar) and five of sul-

phate of copper. For instance, if a solution of one grain of arsenic and three grains of potash, in two drachms of water, are mingled with another solution, of five grains of sulphate of copper in the same quantity of water, the whole becomes converted into a beautiful grass-green mixture, from which a copious precipitate of the same hue slowly subsides, leaving the super-natant liquor transparent and nearly colourless. When the same materials, except with the omission of the arsenic, are employed in a like manner, a delicate sky blue mixture results, so different from the former, as not to admit of the possibility of mistake. In this way one-fortieth of a grain of arsenic diffused through 60 grains of water afforded to Dr. Bostock, by the addition of sulphate of copper and potash, in proper proportions, a distinct yellowish green precipitate. *See Edinburgh Medical and Surgical Journal*, v. 166. In employing this test, it is necessary to view the fluid by reflected, and not by transmitted light, and to perform the experiments by day-light. To render the effect more apparent, a sheet of white paper may be placed behind the glass or test tube in which the mixed fluids are contained.

XXXI. MURIATE OF LIME.

Is of some use as an auxiliary test, for discovering the presence of alcaline carbonates, all of which decompose this salt, and produce with it carbonate of lime. It is further useful in the analysis of vegeta-

ble substances, for detecting the presence of oxalic, malic and tartareous acid, with which it produces a white crystalline precipitate, which is highly insoluble in water, but readily soluble in dilute nitric acid, and the precise nature of which may then be farther examined with less difficulty, so as to discriminate which particular vegetable acid entered into its composition.

Dry muriate of lime is employed also to strengthen spirit of wine, because the affinity of alcohol for water is so strong that it cannot be entirely freed from it by simple distillation. And by muriate of lime this may readily be effected. For this purpose one part of muriate of lime rendered perfectly dry, by having been exposed to a red heat, and powdered after it has become cold, is put into the retort or still; over this, three parts of highly rectified spirit are to be poured, and the mixture well agitated; by distillation with a very gentle heat, about two-thirds of the spirit will then be obtained in the state of perfectly pure alcohol.

XXXII. BENZOATE OF AMMONIA.

Benzoate of ammonia is an excellent test for separating iron from manganese when together in one solution; it is necessary, when employed for this purpose, that the solution containing the two oxides, should be rendered previously neutral with accuracy by the admixture of ammonia, or any other alcali; and then the benzoate of ammonia may be added,

till no more precipitate falls down. This precipitate is benzoate of iron, for all the manganese remains in the solution.

It may however happen that, after having precipitated the iron from the solution containing several kinds of earths and metallic oxides, that part of the benzoate added exists inthe solution in excess; in that case it ought to be destroyed by boiling the solution with some acid, to obviate any confusion which might happen to be produced by the benzoic acid, on the continuation of the analysis.

Benzoate of ammonia not only separates iron from manganese, but it will also detach this metal from all earthy salts, and from nickel, cobalt, zinc, and many other metals, none of which are precipitated by this test, when properly applied; that is to say, if the following circumstances be attended to. Let the solution of the iron, which ought to be in the state of peroxide, be rendered perfectly neutral, by the admixture of ammonia, and dilute it considerably with distilled water. Then let fall into the fluid, drop by drop, the solution of benzoate of ammonia, till no further precipitate appears.

Throw the mass on a filtre, wash the insoluble residue with cold water, and dry the precipitate at a temperature of 212°. The benzoate of iron thus obtained contains 25 per cent. of red oxide of iron, and 75 of benzoic acid and water.

If the benzoate of iron be digested for about 12 hours in liquid ammonia, it becomes completely de-

composed; the red oxide of iron falls down to the bottom of the vessel, and benzoate of ammonia remains in solution. We are indebted to Berzelius for this test. Its utility must be obvious to all, who are employed in analytical labours; because the complete separation of manganese from iron has hitherto been attended with peculiar difficulty.

XXXIII. WATER IMPREGNATED WITH SULPHURETTED HYDROGEN GAS, OR LIQUID SULPHURETTED HYDROGEN

This fluid precipitates many of the genera of metals from their solutions in acids, and produces, with most of them, dark coloured precipitates; and as it affects none of the earths, with the exception of zircon and alumine, it gives us a very valuable agent in analysis. And besides this, some metals may at once be recognised by the colour of the precipitate which they afford with this fluid. For example: with zinc this test produces a white precipitate, with the salts of antimony a bright orange coloured one; arsenic is precipitated yellow; tin, chocolate brown; gold, a dark purple; platina, reddish brown or nearly black. The solutions of lead (page 104) silver (page 86,) mercury, copper and bismuth, are precipitated of a dark brown or black colour. The colours of the precipitates are however very liable to variation, from the state of combination. And, particularly, the degree of oxidizement of the metal in the solution has

a material influence on the colour of the precipitates. Most of the precipitates are compounds of sulphuretted hydrogen with the metallic oxide; or in some cases a decomposition more or less complete, takes place; part of the hydrogen first unites with part, if not all, of the oxigen of the metallic oxide, and reduces it nearly to the metallic state, or to a state of *minimum* of oxidizement, and the remainder of the sulphur and hydrogen unite with the metal, and the whole is separated from the acid of the solution in the form of a coloured precipitate, which therefore is either a sulphuret, or a hydro-sulphuret, of the metal, according to circumstances. Sometimes, too, a small portion of sulphuric acid is formed at the same time, which renders the play of infinities still more complex. Some of the metallic solutions afford no precipitate with sulphuretted hydrogen, or at least the precipitate is redissolved by a slight excess of acid. The metals which afford no precipitate are those chiefly which have a great affinity for oxigen, and which decompose water; namely, iron, cobalt, nickel, manganese, uranium, titanium, and cerium. But some of these metallic solutions become more or less deeply coloured by this test. Thus, if liquid sulphuretted hydrogen be added to a weak solution of red sulphate of iron, the metal becomes reduced immediately to the state of the green or less oxigenized sulphate, and no actual metallic compound falls down; but sulphur is merely precipitated.

EXPERIMENT CXIII.

Dissolve one or two grains of sulphate of zinc (white vitriol) in half a test tube full of distilled water, and add to the solution liquid sulphuretted hydrogen. The zinc will become precipitated in the form of a *white* gelatinous sediment, which is a hydro-sulphuret of zinc.

EXPERIMENT CXIV.

Dissolve a few grains of tartrite of antimony and potash (emetic tartar) in a test tube full of distilled water; and drop into the solution, gradually, liquid sulphuretted hydrogen; a bright *orange* coloured precipitate will be obtained.

EXPERIMENT CXV.

Mingle a small quantity of the solution of arsenious acid with half a test tube full of distilled water, and add to the mixture liquid sulphuretted hydrogen; *a yellow* precipitate will immediately be produced.

EXPERIMENT CXVI.

Let fall a few drops of sub-muriate of tin into half a wine glass full of distilled water, and add to the mixture liquid sulphuretted hydrogen; a *chocolate brown* precipitate will be produced.

EXPERIMENT CXVII.

Mix a few drops of muriate of gold with half a test tube full of distilled water, and add to the mix-

ture liquid sulphuretted hydrogen; a dark *orange brown* precipitate will fall down, which is sulphuret of gold, and which is composed of 80.39 gold, and, 19,61 sulphur. (*Thompson's Annals*, No. 2, 1813, *p.* 141.) When exposed to heat it gives up its sulphur, and the residue is metallic gold.

EXPERIMENT CXVIII.

Add to half a test tube full of distilled water from ten to twenty drops of muriate of platina; and drop into the mixture liquid sulphuretted hydrogen; a *black* precipitate will take place, which becomes reddish brown, with an excess of the test. It is according to Berzelius a perfect sulphuret of platina.

XXXIV. TINCTURE OF GALLS.

This is an excellent test for detecting the presence of iron. It produces, with this metal, a violet or black precipitate, whether the iron be held in solution by carbonic acid, or by any other acid. If the iron be dissolved in carbonic acid, as is often the case in mineral waters, the solution, after having been concentrated by boiling, is no longer tinged of a violet or black colour; but if it be held in solution by any other acid, the test still continues to produce a black precipitate. When the quantity of iron is exceedingly small, as is in general the case in Chalybeate waters, tincture of galls does not actually produce a sensible precipitate, but only a slight purple tinge. A neat way of applying this test in cases, where the

quantity of iron is very small, consists in suspending a slice of the gall-nut by a silken string in the water to be examined. The iron, in order to afford a purple or black precipitate with tincture of galls, must be in the state of red oxide, and if oxidized in a less degree, the effect will not be instantaneous, but will only take place after leaving the mixture to stand some time in contact with the air. The black colour can however be also rendered apparent, even in solutions of iron containing the metal in a lower state of oxidation, by causes which cannot change the state of oxidation, as by dilution with water, or by the addition of a little alcali; and the reason therefore of it not appearing when the solution contains the iron at a *minimum* of oxidation is, that the oxide in that state is retained by a stronger attraction in combination with the acid, than when the oxidation is more perfect.

The action of this test is influenced by the presence of other bodies. For example; if alcalies and earthy carbonates are present, it then produces, with iron, a violet colour. If neutral alcaline salts are present, the colour is deepened, or of a dark purple; the presence of sulphate of lime renders the colour of the precipitate at first whitish, and afterwards black; and carbonate of lime produces the same effect.—A dark purple colour indicates other alcaline salts; purplish red denotes sulphuretted hydrogen. Mr. Phillips has shewn that carbonate of lime has a

considerable effect on the production of colour, by the action of tincture of galls on salts of iron. When the iron is in a low degree of oxidizement, it rather heightens the colour: while, when it is at the maximum of oxidizement, it diminishes it so much, that, if the iron be present in very minute quantity, it may even not be capable of being detected by this test.—He has thus been enabled to explain a fact before inexplicable, which had given rise to various opinions with regard to the hot waters of Bath; namely, that when taken immediately from the spring, and while hot, they give indication of a small quantity of iron, by the test effusion of galls, while, when they have cooled under exposure to the air, so that the iron becomes more oxidized, they appear, from the same test, to contain none, though no iron is deposited during the cooling.

Tincture of galls produces, with the solutions of osmium, a vivid blue colour. With the solution of tellurium it affords a yellow precipitate—with solutions of mercury an orange coloured precipitate.—Silver is precipitated of a white colour—uranium, brown—but the colour of the precipitates of these metals is upon the whole exceedingly variable, according to the combination or state of existence of the metal, and its degree of oxidizement.

EXPERIMENT CXIX.

Impregnate a quantity of distilled water with carbonic acid gas, shake it up for a few minutes with a

small quantity of iron filings, let the mixture stand for about 24 hours, and then decant or filtre it. Take half a wine glass full of this chalybeate water, and add to it a few drops of tincture of galls. The mixture will assume a violet colour, and a black precipitate will become deposited, composed of gallic acid, tan, and oxide of iron.

EXPERIMENT CXX.

Take another portion of the same chalybeate water, concentrate it by boiling to about one half of its bulk, and when it is become cold, filtre it; a brown precipitate (carbonate of iron) will fall down. The remaining clear fluid will no longer be altered by tincture of gall, which shows that the iron was combined with an excess of carbonic acid, which held it dissolved in the water.

EXPERIMENT CXXI.

Add to two or three ounces of distilled water five or six drops of sulphuric acid, together with a small quantity of iron filings, shake the mixture for a few minutes, and let it stand till it is become perfectly clear, or it may be filtered after having stood 8 or 10 hours.

To one-half of this clear solution of iron add a few drops of tincture of galls; a violet colour, which speedily darkens, will immediately appear.

Boil the other half of the fluid, till it is concentrated to about one half of its original bulk; a brown

powder will separate from the solution during the process. When the fluid is cold, filtre it, and examine it again, by adding to it a few drops of tincture of galls; which will still occasion a violet or black colour, because the iron is combined with a mineral acid. A minute quantity of sulphate of iron, dissolved in distilled water, will give the same results.

The black or violet coloured precipitate, which this test produces with the solutions of iron, is a combination of oxide of iron with the gallic acid and tan, contained in the tincture of galls. In order that the iron may produce immediately a black precipitate, it must be in the state of red oxide; for the less oxidized iron does not form instantly a black precipitate with these bodies; but the tendency of the oxide of iron in the green sulphate to receive a larger proportion of oxygen into the combination is, however, such, that it is difficult to prevent a black precipitate from being obtained a few moments exposure to the atmosphere, or the action of the oxygen even of the air contained in the upper part of the test tube, is sufficient to communicate a violet tint. The brown precipitate which is produced when a solution of green sulphate of iron is boiled, (Experiment CXXI) is owing to part of the protoxide of iron passing to the state of per-oxide, and combining with a portion of acid, falls down in the form of a brown powder, which is a sulphate of the per-oxide with *excess of base*, or a sub-sulphate of iron.

EXPERIMENT CXXII.

The effects of a sympathetic ink may be obtained by writing on paper with a dilute solution of green sulphate of iron; when the writing is dry, no letters are visible; and if a feather, or sponge moistened with tincture of galls, be passed over the paper, the writing will instantly become visible, and assume a black colour.

XXXV. SULPHATE OF COPPER AND AMMONIA.

This test, which is of a very fine azure blue colour, may be applied for discovering arsenic when contained in a liquid. It produces, with it, a yellowish green precipitate, which, after being separated from the super-natant fluid, dried, and put upon ignited coals, produces the peculiar garlic-like odour, which is characteristic of arsenic when in contact with red hot coals. The precipitate is not soluble in water, nor in a solution of arsenious acid, unless added largely in excess, but it is soluble in liquid ammonia, and in nitric and most other acids.

EXPERIMENT CXXIII.

Into half a wine glass full of distilled water let fall a few drops of the solution of arsenious acid, and add to it a few drops of solution of sulphate of copper and ammonia; a yellowish or pea green precipitate will ensue, which, if collected, dried, and laid on an ignited piece of charcoal, will diffue the pecu-

liar garlic like odour, which characterises arsenic when heated with combustible bodies.

EXPERIMENT CXXIV.

Divide the whole of the fluid, together with the precipitate of experiment CXXIII. into four parts, and add to one a little distilled water only; to the second, a few drops of the solution of arsenious acid; to the third, liquid ammonia; and to the fourth, acetic, nitric, or any other acid. On the addition of water, no alteration will be perceived any more than from the solution of arsenious acid; but if the latter be added in great quantity, the precipitate becomes re-dissolved; a few drops of liquid ammonia will also immediately dissolve the precipitate, and a blue transparent fluid will be obtained, and a little nitric acid, added to the fourth part, will in a like manner dissolve the precipitate, and form with it a colourless solution.

XXXVI. SUB-BORATE OF SODA,

Or common borax, when deprived by fusion, of its water of crytallisation, becomes glass of borax, an excellent flux for all earthy substances and metallic oxides, and is employed as such in the blow-pipe assays.

It likewise renders an essential service in the operation of analyzing argillaceous minerals; these substances, which are but feebly acted on when fused with alcalies, yield readily to glass of borax. Corun-

dum, and the hardest gems, may be subdued by fusion, by means of this salt.

XXXVII. SUB-MURIATE OF TIN.

This is a delicate test for platina, with the solutions of which it produces an orange coloured precipitate. It is also used as a test for detecting gold, with the solutions of which it affords a purple coloured precipitate, well known by the name of *purple precipitate of Cassius;* and used to give a red colour to porcelain and glass. Sub-muriate of tin has likewise been recommended as a test for detecting albumen, which it precipitates from its solution, but less actively than corrosive sublimate (see page 71;) for water containing 1-200 of albumen is not altered by this test immediately, but only after the mixture has been suffered to stand some hours. With the neutral salts of palladium, this test gives a dark brown precipitate, but if added to excess, the liquor remains transparent, and of a fine emerald green colour. It also produces a dark brown precipitate, with a solution of corrosive sublimate of mercury. It is absolutely essential that the test be fresh prepared; or at least the tin which it contains should be at a *minimum* of oxidation.

EXPERIMENT CXXV.

Mix a drop of muriate of platina with a wine glass full of distilled water, and add to the mixture

a drop or two of sub-muriate of tin; a dense orange coloured precipitate will fall down.

EXPERIMENT CXXVI.

Add to a wine glass full of distilled water one drop of muriate of gold, and let fall into this fluid a few drops of sub-muriate of tin; a purple coloured precipitate will be obtained, consisting of oxide of tin and gold.

The colour and quantity of the precipitate is extremely various, from circumstances not easily appreciated. Its production is owing to the strong attraction of the tin to oxigen, and the large quantity of that principle with which it is disposed to combine. When the two solutions are mixed, the oxide of tin being at the minimum of oxidizement, attracts part, or the whole of the oxigen of the oxide of gold; the two oxides, thus brought to states of existence different from those in which they were present in the separate solutions, are no longer soluble, are precipitated in combination. This theory also points out the circumstances required to be attended to in the process, to obtain the precipitate uniform; the whole depends on having the solution of tin at the minimum of oxidizement, or as nearly so as possible; and hence it must be used newly prepared, as otherwise the tin passes to too highly an oxidated state, and the effect of the test is lost.

The colour of the precipitate approaches more to a violet, as the muriate of tin bears a larger propor-

tion to that of gold, and the colour communicated by this precipitate to porcelain has the same variable character. When the sub-muriate of tin is in excess, the precipitate is more of a rose colour. A violet coloured precipitate M. Oberkampf found to contain 60 per cent. of oxide of tin, and 40 of metallic gold, and a fine purple coloured precipitate contained 20 1-2 per cent of tin, and 79 1-2 of gold.—From the experiments of M. Duportal, it appears that the degree of dilution influences much the quantity of the precipitate; so that when a very weak solution of muriate of gold and muriate of tin be employed, one part of gold will produce as much as 5 1-2 parts of purple precipitate.

EXPERIMENT CXXVII.

Let fall into a test tube half filled with distilled water one drop of a solution of oxy-muriate of mercury, and add to the mixture a drop of sub-muriate of tin; a dark brown precipitate will instantly be produced.

Sub-muriate of tin has a strong tendency to acquire a further proportion of oxigen; it should therefore be preserved in a well stopped bottle.

XXXVIII. LIQUID AMMONIA.

Caustic, or liquid ammonia, is chiefly employed in analytical experiments, for discovering copper and

nickel, with the solutions of which, when added in excess, it produces a clear sapphire blue colour.

To discriminate to which of these metals the blue colour be owing, it is only necessary that the ammonial solution be saturated in excess with sulphuric or nitric acid, and then immersing into it a slip or bar of zinc; this metal will precipitate copper, if the colour be owing to that metal, but with nickel it produces no effect; a mud coloured precipitate indeed is not unfrequently deposited from a solution of *common* nickel, but this precipitate is for the most part arsenic and iron, with which nickel purified in the usual way always abounds; and when all the arsenic capable of precipitation by this method has fallen down, no further digestion with zinc will produce the least effect. The solution of oxide of nickel in ammonia is decomposed, according to Mr. Phillips, by the addition of soda or potash; and he has pointed out this as affording a certain and easy method of obtaining, what is otherwise very difficult, nickel free from cobalt; the oxide of the latter, when dissolved in ammonia, being very slowly and sparingly precipitated by potash, while that of the former is precipitated immediately and largely. He ascribes these decompositions to the two alcalies combining, and thus weakening the affinity of either to the metallic oxide.

Liquid ammonia produces with zinc a white precipitate, which again becomes dissolved by a more

more copious admixture of the test. Liquid ammonia renders great services to the practical analyst, by enabling him to discriminate, in many cases, saline compounds with a base of lime from those of magnesia; because it precipitates the salts of magnesia *partially*, but not the salts of lime; at least the latter are not precipitated, when lime alone is present. Certain precautions are however necessary in the application of this substance; because, although magnesia cannot be precipitated entirely from any of its solutions by ammonia, yet, if alumine be present, its precipitation is complete. Thus, Chevenix found, that on adding an excess of ammonia to a solution of muriate of magnesia, mixed with a large proportion of muriate of alumine, nothing remained in the solution but muriate of ammonia: the two earths were precipitated in combination, and the affinity of the alumine to the magnesia had so much aided the decomposition, as to render it complete; and this affinity between the two earths was even sufficient to resist the action which potash is capable of exerting on alumine. And further; if in the examination of a liquid (for instance a mineral water) containing carbonic acid, either in a free state, or combined with magnesia, liquid ammonia be employed, it will take part of the excess of the carbonic acid from the magnesia, and the carbonate of ammonia will then throw down carbonate of lime; and if salts of alumine be present, they will likewise be affected.

It is of the greatest importance to be aware of the remarkable property which this re-agent possesses, of forming triple salts, either with earths of metallic oxides, as is the case when sulphate of magnesia, sulphate of lime, and sulphate of iron, occur together. In such a case, for example, the excess of acid (if any) must first be neutralized by ammonia; if succinate of ammonia be then added, the iron, if in a high state of oxidation, will become precipitated, (see *succinate of ammonia*) and the earths remain untouched.

Or the solution may be evaporated to dryness, and then exposed to a dull red heat for at least one hour. By this means the sulphate of iron becomes decomposed, its oxide of iron is left behind, and the sulphate of lime will be rendered insoluble, whilst the sulphate of magnesia is not altered. If the mass be then digested in water, the sulphate of magnesia becomes dissolved.

If sulphate of iron and sulphate of magnesia are alone present in a fluid, the insoluble residue will of course be oxide of iron.

Sulphate of lime and sulphate of magnesia may also be separated by the following methods: If the quantity of sulphate magnesia is comparatively small, with regard to the sulphate or lime, liquid ammonia, when added to the solution, will separate a portion of the magnesia (but not all) and the sulphate of lime will not be acted on, provided the mixture be kept

for some hours in a well corked bottle, to prevent it from absorbing carbonic acid of the atmosphere. But as it is more commonly required to separate sulphate of lime from a larger quantity of sulphate of magnesia, advantage may be taken of the very difficult solubility of the former, and the ready solubility of the latter. The mixed solutions therefore should be concentrated highly by evaporation; when, after some hours repose, most of the sulphate of lime will separate alone, and may be removed. The solution may then be evaporated to dryness, and strongly heated, and next pulverised and digested with three or four times its weight of cold water, by which the whole of the sulphate of magnesia will be dissolved, and what little sulphate of lime may remain, after the first process, will be left untouched. The solution may then be boiled with sub-carbonate of potash, to decompose the carbonate of magnesia, and the latter, when washed, dried, and ignited in a strong red heat, will be magnesia.

Liquid ammonia may also be employed as an useful re-agent, to separate oxide of iron from oxide of manganese; for this fact we are indebted to Mr. Hatchett; his method is as follows: pour into the solution of the mineral in muriatic acid, diluted with water, liquid ammonia, till the mixture slightly restores the blue colour of reddened litmus paper. The oxide of iron will thus be separated, and remain on the filtre upon which the liquor is thrown, and the oxide of manganese will pass through it, in a

state of solution combined with muriatic acid. To obtain it from this solution, it is only necessary that the fluid be evaporated to dryness, and exposed to a red heat, to expel the muriate of ammonia.

EXPERIMENT CXXVIII.

Add three or four drops of the solution of sulphate of copper to half a test tube full of distilled water, no change will take place; but if a few drops of liquid ammonia be added, in excess, the mixture will assume a fine sapphire blue colour, and thus indicate the presence of copper. This experiment may be pleasingly varied in the following manner.

EXPERIMENT CXXIX.

Write on paper with a solution of sulphate of copper; the characters or writing will be of a green colour (or when the solution is dilute, the letters will be invisible) and if the paper be held over the surface of liquid ammonia contained in a glass or saucer, the writing will assume a beautiful blue colour, which departs again on moving the paper near a fire, or by suffering it to be exposed to the open air for some time.

The presence of copper when contained in pickles, to which a beautiful green colour has been given, according to the directions of the most popular cookery books, by boiling them with half-pence, or allowing them to stand for 24 hours in copper or brass pans, (*See English Housekeeper, by E. Raf-*

fald, p. 352, 354.) may thus be detected. It is only necessary to mince the suspected pickles, and to pour liquid ammonia diluted with an equal bulk of water over them in a stopped phial; if the pickles contain the minutest quantity of copper, the ammonia will assume a blue colour.

EXPERIMENT CXXX.

Dissolve a few grains of sulphate of zinc (white vitriol) in half a test tube full of distilled water, and add liquid ammonia to the solution drop by drop; a gelatinous precipitate will be produced; which disappears again by a more copious admixture of the test.

EXPERIMENT CXXXI.

Dissolve five or six grains of sulphate of magnesia in half a test tube full of distilled water, and add to the solution liquid ammonia; part of the magnesia only will be precipitated; the rest remains in solution, and, by evaporating the super-natant fluid, a triple salt will be formed, consisting of sulphuric acid, magnesia, and ammonia.

Liquid ammonia is known to be perfectly deprived of carbonic acid, or fit to be used as a test, when it gives no effervescence with acids, no cloudiness on mixture with strong alcohol, and particularly when it does not alter the transparency of a solution of pure lime (calcareous spar, or Carrara marble) in nitrous, muriatic, or acetic acid. This last, which is a

most delicate test, should be made in a well corked bottle; for though liquid ammonia will not precipitate lime, carbonated ammonia will do it very readily, and the alcali, if exposed to the air, will speedily absorb from it sufficient carbonic acid to render this test fallacious. Besides this, it should yield no precipitate with oxalic acid. If muriate of ammonia is accidentally mixed with the liquid ammonia in the process of distillation, the presence of the muriatic acid is thus detected: saturate part of the liquor with distilled vinegar, and add to it a few drops of nitrate of silver, a white precipitate will then indicate the muriatic acid; for nitrate of silver is not clouded by pure acetate of ammonia.

XXXIX. OXALATE OF AMMONIA.

This salt is the most delicate test for lime, with which it produces a white insoluble precipitate; its power is very great. One grain of lime may be detected by it in 42.250 of water. It also occasions a cloudiness in fluids containing magnesia, but then its action is comparatively very feeble. The precipitate, when a small quantity of magnesia is present, does not take place *immediately*, but only after some hours standing; and, besides this, the magnesia must be present in considerable quantity, whilst, on the contrary, the minutest portion of lime is immediately affected by this test.

If oxalate of ammonia occasions a white precipitate before, and not after, having boiled the fluid

submitted to its action (for instance a mineral water) the lime is dissolved by an excess of carbonic acid; and if it continues to produce a precipitate in a liquid which has been concentrated by boiling, we then are convinced that the lime is combined with a fixed acid. From the quantity of the precipitate produced, we are enabled to determine the quantity of lime which the substance contains. To render this test decisive, the following precautions are however necessary: 1. The mineral acids, if any be present, must be previously saturated with an alcali. 2. Barytes, and strontia, if present, must be previously removed by sulphuric acid.

The quantity of lime contained in the precipitate may be known, by first igniting it with access of air, which converts the oxalate into a carbonate of lime; and by expelling from this last the carbonic acid, by a red heat in a covered crucible. According to Dr. Marcet, 117 grains of sulphate of lime give 100 of oxalate of lime, dried at 160 degrees Fahrenheit.

EXPERIMENT CXXXII.

Impregnate a small quantity of distilled water with carbonic acid, and shake the water up, for some minutes, with a small portion of powdered white marble, or chalk; suffer it to stand for at least two days, and then filter it.

To one half of this solution add a few grains of oxalate of ammonia, the fluid will immediately become turbid, and, after some time, a white powder (oxalate of lime) will fall to the bottom.

Boil the other half of the liquor over the lamp furnace for a little while; during this process, the fluid will become turbid, and a white precipitate (carbonate of lime) will be deposited; and the liquid, after having also been filtered when cold, will now no longer be rendered turbid by the test, because the carbonic acid, which held the lime in solution by virtue of an excess of carbonic acid, being volatilized, the lime becomes precipitated in the form of carbonate of lime (see page 92.)

EXPERIMENT CXXXIII.

Make a mixture, composed of three ounces of distilled water, a few grains of powdered white marble, or chalk, and a few drops of muriatic acid; shake the mixture for five or six minutes, and suffer it to stand till it is become perfectly clear. Pour off half a wine glass full of the fluid, and add to it a few grains of oxalate of ammonia; the solution will immediately become turbid, and oxalate of lime will be deposited, in the form of a white powder.

Having concentrated by boiling another portion of the solution, examine it in like manner with oxalate of ammonia; and it will also afford a white precipitate; because the acid which holds the lime dissolved cannot be volatilized by heat.

EXPERIMENT CXXXIV.

Pour a few drops of a solution of oxalate of lime into a test tube full of lime water, and the same phenomena will take place as in the preceding Experiment.

EXPERIMENT CXXXV.

Pour a little oxalate of ammonia into a tumbler full of common spring water; the water will become milky, and a white precipitate will fall down, because spring or pump water always contains a portion of lime, combined either with sulphuric or carbonic acid; or sometimes both sulphate and carbonate of lime are present.

EXPERIMENT CXXXVI.

Dissolve one or two grains of sulphate of magnesia in a test tube full of distilled water, and add to it a few grains of oxalate of ammonia; the solution will not become turbid. This experiment shows that magnesia does not form a salt of so difficult a solution as lime does with oxalic acid, and that, consequently, the presence of magnesia is no material obstacle to the detection of lime by means of this test. If again a few grains or more of sulphate of magnesia are added to the before mentioned quantity of water, and if to this several grains of oxalate of ammonia are added, the solution even then does not become turbid, although it be suffered to stand for some days.

XL. PRUSSIATE OF POTASH.

This is one of the most important tests ever discovered, because it has the valuable property of forming a precipitate with all metallic solutions, except those of platina, gold, antimony, tellurium, iridium, rhodium, and osmium; and from the colour of the

precipitate the particular metal may in many cases be inferred, and its quantity ascertained by easy means. It is chiefly used for detecting iron. If this metal exists in a state of high oxidizement in any fluid, it produces, with this test, a Prussian blue precipitate; and when in a low state of oxigenation, the precipitate is white; but even then it very rapidly assumes a blue colour on mere exposure to the air. Copper is precipitated brown; zinc and tin afford a white gelatinous precipitate; and cobalt a distinct olive green one. Bismuth gives with it a yellow precipitate. It is not affected by any of the earths. It is a very useful test for the analysis of mineral waters. If a mineral water, taken fresh from the spring, affords a blue precipitate with prussiate of potash, but not after having been concentrated by boiling, it may be inferred that the iron is present in the water, in combination with carbonic acid. And if the test continues to strike a blue colour with the boiled or concentrated water, the acid which held the iron in solution is a mineral acid, the nature of which may be readily discovered by the appropriate tests for acids; namely, by the salts of barytes (page 152, 153), or those of silver, (page 77.)

It is stated by some authors, that alumine is also precipitated by prussiate of potash: such a statement is erroneous. The error has arisen from the application of an impure test; and many of the contradictory results of mineralogical analysis, by different

chemists, are probably to be ascribed to a similar cause; but with barytes this test produces a *chrystalline salt*, and this peculiar character which the test presents was regarded as in some measure assimilating barytes with the metals, the solutions of which are so generally precipitated by this test. Meyer and Klaproth observed, however, that no such precipitation from the solutions of barytes takes place *immediately*, unless when the prussiate employed is contaminated with a sulphate, from which it is difficult to obtain it free. Dr. Henry has shown, that, although no *immediate* precipitate is formed on the addition of prussiate of potash to a barytic salt, when the prussiate is pure, yet in a few hours small crystals are deposited from the liquor; but these crystals consist of prussiate of barytes, which proves that the salts have, in part at least, exchanged their principles; and this, as Guyton has remarked, is not peculiar to this earth; a similar exchange happens with the salts of other earths and alcalies. Dr. Henry observes, likewise, that the same crystals are formed from barytic water added to the prussiate.

EXPERIMENT CXXXVII.

To three or four ounces of distilled water impregnated with carbonic acid gas, or common seltzer water, add a few iron filings, or iron wire, and let it stand in a corked phial for three or four days, occasionally shaking the mixture, and then filter the so-

lution, which will be an artificial chalybeate aerated water. To one half of it add a grain or two of prussiate of potash; the liquid will become blue, and some time after a blue precipitate will be deposed.

EXPERIMENT CXXXVIII.

Evaporate the other half of the chalybeate aerated water, obtained in Experiment CXXXVII. to one half of its bulk, a brown powder, or sub-carbonate of iron, will fall down. When the water has become cold, filter it, and assay it again with prussiate of potash, which will now produce no effect; because the excess of carbonic acid, which held the iron in solution, is volatilized, and the iron, thus reduced to a sub-carbonate of iron, is no longer soluble in the water.

EXPERIMENT CXXXIX.

Shake two or three ounces of distilled water, with thirty or forty grains of iron filings, and five or six drops of sulphuric acid, for a few minutes; let the mixture stand for a day or two, and decant or filter it, (or dissolve a few grains of sulphate of iron in half a wine glass full of distilled water:) to one half of this clear solution add a few drops of a solution of prussiate of potash, and a blue precipitate will be formed.

If the other half of the fluid be evaporated a little, and the same test be added to it, a blue precipitate

will nevertheless be produced; because the iron is held in solution by a mineral or fixed acid, which cannot be volatilized by heat.

EXPERIMENT CXL.

Put into one wine glass, half filled with distilled water, a few grains of prussiate of potash, and in another glass, containing a like quantity of distilled water, dissolve a grain of green sulphate of iron; pour the solutions together when the salts are dissolved, and an olive green precipitate will be produced, which will speedily acquire a blue colour.

The effect of a sympathetic ink may be obtained by means of this re-agent; namely, writings made on paper with a dilute solution of sulphate of iron, when dry, are invisible; but by passing a feather or sponge, wetted with a solution of prussiate of potash, over the characters, the letters will become visible, and appear of a blue colour. The experiment may be reversed, by writing with prussiate of potash, and rendering the characters visible by sulphate of iron.

EXPERIMENT CXLI.

Dissolve about one drachm of green sulphate of iron in two ounces of water; add to the solution one or two drachms of clean (not rusty) iron filings; boil the mixture briskly for about five minutes, and filtre the fluid. Add a drop of this solution to a test tube full of water, and let fall into the liquor, also, a few

drops of a solution of prussiate of potash, and then cork the tube immediately. A copious *white* precipitate will fall down, which is white prussiate of iron, and which soon becomes green; but if the tube remains corked, the white colour does not deepen nor alter by exposure to light.

The iron in this solution is at a *minimum* of oxidisement, by being digested with metallic iron; it yields therefore a white precipitate with prussiate of potash.

EXPERIMENT CXLII.

Add a few drops of nitric acid to the solution of sulphate of iron prepared in experiment CXLI, and again test it with prussiate of potash; it will now produce prussian blue, because the iron having received oxigen from the nitric acid, and being higher oxidated, yields a blue precipitate with this test.

EXPERIMENT CXLIII.

Dissolve a grain of prussiate of potash in half a test tube full of distilled water, and add to the solution a drop or two of a solution of sulphate of copper: a *brown* precipitate (prussiate of copper) will immediately be produced.

EXPERIMENT CXLIV.

Put a grain of sulphate of zinc (white vitriol) into a test tube full of distilled water, and add to the solution a few drops of prussiate of potash, a gelatinous *white* precipitate (prussiate of zinc) will fall to the bottom

—which *again becomes dissolved* by the addition of liquid ammonia.

EXPERIMENT CXLV.

Add a few drops of the solution of sub-muriate of tin to a test tube full of distilled water, and let fall into the mixture a few drops of prussiate of potash; a very dense *white* gelatinous precipitate (as in experiment CXLV.) will be produced, which does *not* become re-dissolved by the addition of liquid ammonia; it is prussiate of tin.

EXPERIMENT CXLVI.

Let fall a few drops of the solution of nitrate of cobalt into half a wine glass full of distilled water, and add prussiate of potash to the mixture; a pale *olive green* precipitate (prussiate of cobalt) will be produced.

EXPERIMENT CXLVII.

Add to half a test tube full of distilled water two or three drops of a solution of muriate of bismuth, previously mixed with a little muriatic acid (to prevent the muriate of bismuth from being decomposed by the water) and drop into the mixture prussiate of potash; a sulphur *yellow* precipitate, or prussiate of bismuth, will be produced.

EXPERIMENT CXLVIII.

Let three test tubes be half filled with distilled water; put into the first a drop or two of muriate of

platina; into the second put a like quantity of muriate of gold; and into the third a solution of super-tartrite of potash and antimony. If, to either of these solutions, prussiate of potash be added, no change will take place, because the metals which form the bases of these salts are some of those which are not precipitable by this re-agent.

EXPERIMENT CXLIX.

Arrange three separate wine glasses, half filled with distilled water; pour a few drops of a solution of sulphate of magnesia into the first glass; add muriate of lime to the second, and a solution of alum to the third glass. If prussiate of potash be added to these solutions, no change will take place, because none of the earths contained in these salts are precipitable by prussiate of potash.

In using prussiate of potash for detecting the quantity of iron in a fluid, when no other metal is present, it requires considerable caution to attain accurate results. The prussiate should on all occasions be previously crystallized, and the quantity of oxide of iron essential to its constitution, or at least an invariable accompaniment, should be previously ascertained, which may be done in the following manner: expose a known weight of the crystallized salt to a low red heat in a silver crucible, by which means the prussic acid becomes destroyed, and the potash and oxide of iron is left behind; wash off the soluble part with distilled water; collect the rest on a filtre;

dry it, and again calcine it with a little wax, and let it be again weighed : the result shows the proportion of oxide of iron contained in the salt. This varies from 22 to 30 *per cent.;* when the quantity of iron is greater, the test is unfit for use, because it deposits Prussian blue by the contact of acids. When the test is therefore employed for discovering the quantity of iron contained in any liquid, let a known weight of the salt be dissolved in a given quantity of water; add the solution gradually, and observe how much is expended in effecting the precipitation, and, before collecting the precipitate, warm the liquid, which generally throws down a further portion of Prussian blue. Let the whole be washed and dried, and then ignite the residue with wax. From the weight of the oxide, thus obtained, deduct the quantity of iron, which, by the former experiment, is known to belong to the prussiate which has been added, and the remainder denotes the quantity of oxide of iron present in the liquor under examination.

On account, however, of the great difficulty of preparing this test with a constant or uniform portion of iron, it is seldom employed (but it certainly may) for ascertaining the *quantity* of iron in solutions; but only its presence.

Prussiate of potash, when in solution and kept exposed to the light for some time, becomes partly decomposed, and hence it should be preserved in an opake bottle. It is difficult to explain this change.

XLI. PRUSSIATE OF AMMONIA.

This re-agent is of use only in the analysis of saline substances. It may happen, for example, that a fluid contains neutral salts with alcaline bases, together with metallic salts. In this case, prussiate of potash cannot be well applied to separate the metallic salts; because it then would be difficult to ascertain whether the alcaline salts were originally present in the solution or not. But if prussiate of ammonia be employed, no ambiguity can result. For the metallic salts need only be precipitated by this test, and the earths by carbonate of ammonia, in a temperature of 180° or upwards, in order to ensure the decomposition of magnesian salts, which this carbonate does not effect in the cold. The liquor may then be separated by filtration, and boiled to dryness, and the dry mass exposed to such a heat as is sufficient to expel the ammoniacal salts. This application of heat will drive off, also, any excess of the ammoniacal carbonate, which might have retained in solution either yttria, glucine, or zircon. The alcaline salts may be separated from these earths, by boiling the mixture in water, and filtering and evaporating it. The salts with bases of fixed alcalies will remain unvolatilized. By this process, indeed, it will be impossible to ascertain whether ammoniacal salts were originally present; but this may be easily learned, by adding to the salt under examination, before its solution in water, potash, which, if

ammonia be contained in the salt, will produce the peculiar smell of that alcali.

XLII. PRUSSIATE OF MERCURY.

This combination of prussic acid with mercury is a delicate test for palladium, which it separates in the form of a yellowish white precipitate (prussiate of palladium) from all its solutions—the solution of palladium should be neutral. The precipitate thus formed has the property of detonating, when heated. The noise is similar to that occasioned by firing an equal quantity of gunpowder: and accordingly the explosion is attended with no marks of violence, unless occasioned by close confinement. The heat requisite for the purpose is barely sufficient to melt bismuth, and the light produced is feeble, and can be seen only in the absence of all other light. By means of this re-agent, Dr. Wollaston has pointed out a method of obtaining palladium with facility from the ore of platina. The process is as follows: let any quantity of platina of commerce be dissolved in a sufficient quantity of nitro-muriatic acid, and free the solution as much as possible of its excess of acid (if it contains any) by evaporation, or by the addition of an alcali. This being done, mingle the solution with prussiate of mercury, until no farther cloudiness ensues, taking care to leave the mixture to stand for some minutes. The yellowish-white precipitate, which is then deposited, is prussiate of palladium. To obtain the palladium in a pure state, let the pre-

cipitate be heated to redness, and palladium will be obtained in a state of purity, amounting to about four or five tenths *per cent.* upon the quantity of the ore of platina employed. It is no matter whether the solution of the ore of platina has been rendered neutral by evaporation of the redundant acid, or saturated by the admixture of potash, of soda, or ammonia, by lime or magnesia, by mercury, by copper, or by iron; or whether the platina has, or has not, been precipitated from the solution by muriate of ammonia. The prussiate of mercury acts equally well in either case: for prussiate of mercury Dr. Wollaston found peculiarly adapted to precipitate palladium, exclusively of all other metals, on account of the great affinity of mercury for the prussic acid, which in this case prevents the precipitation of iron or copper. The decomposition of muriate of palladium by prussiate of mercury, Dr. Wollaston observes, is not effected solely by the superior affinity of mercury for muriatic acid, but is assisted also by the greater affinity of prussic acid for palladium; for he observed that prussiate of palladium may be formed by boiling oxide of palladium in a solution of prussiate of mercury.

XLIII. BARYTIC WATER

Is a very effectual test for detecting the presence of free or combined carbonic acid, with which it forms a precipitate, which is soluble with effervescence in dilute nitric or muriatic acid; it is also a most sensible test of sulphuric acid, and all its com-

binations, which it indicates by a precipitate, which is not soluble in water nor in dilute muriatic or nitric acid.

Barytic water may likewise be employed for separating strontia from barytes; this operation is founded on the stronger affinity of barytes than of the former earth for acids. Hence, if barytes and strontia be present in the same solution, barytic water may be added till no further precipitate falls down; the barytes seizes the acid, and the strontia becomes precipitated. The solution of strontia should have no excess of acid, which would prevent the action of the barytic earth.

EXPERIMENT CL.

Drop barytic water into water impregnated with carbonic acid gas; a copious white precipitate, which is carbonate of barytes, will fall down. Add nitric or muriatic acid to the mixture, and the precipitate will become re-dissolved.

EXPERIMENT CLI.

Blow the air respired from the lungs through barytic water, by means of a quill or glass tube; a white precipitate (carbonate of barytes) will fall down, originating from the carbonic acid gas contained in the air respired from the lungs. See page 32 and 92.

EXPERIMENT CLII.

Pour some barytic water from one glass vessel into another repeatedly; it will speedily become tur-

bid, and a white precipitate will fall down; this shows that carbonic acid gas is contained in the atmosphere, which, combining with the dissolved barytes, forms carbonate of barytes. Hence, also, if barytic water be left exposed to the common air, it will soon be covered with a thin white pellicle, which, when broken, will fall to the bottom of the vessel, and be succeeded by another; and this may be continued, till the whole of the barytes is separated from the water.

EXPERIMENT CLIII.

Let fall a single drop of sulphuric acid into a tumbler full of distilled water, no alteration will follow; but if a little barytic water be added, a white precipitate, or sulphate of barytes, will immediately be produced, which is not soluble in any dilute acid.

EXPERIMENT CLIV.

Drop barytic water into a decanter full of common spring or pump water; an immediate cloudiness will ensue, and a white precipitate will gradually fall down, which likewise does not disappear again, (Experiment CLVI,) by the admixture of dilute muriatic or nitric acid; because spring or well waters always contain a minute quantity of sulphate of lime, or other salts containing sulphuric acid; and this acid joins the barytes, and produces the white insoluble precipitate, or sulphate of barytes.

EXPERIMENT CLV.

To a solution of a few grains of sub-carbonate of potash, or of soda, in half a wine glass full of distilled water, add barytic water, which will immediately produce a turbidness; because the barytes separates the carbonic acid from the sub-carbonated alcali, and falls down with it in the state of a carbonate of barytes. By adding a sufficient quantity of the solution of barytes, the whole of the carbonic acid may thus be taken away from a carbonated alcali, and the alcali remains perfectly pure, or at least free from carbonic and sulphuric acid.

This re-agent may also be employed for purifying rain water, so as to render it fit for chemical researches. Rain water collected from the roofs of houses, not the first water which is directly received from the gutters at the commencement of a shower, but that which descends after the rain has sufficiently washed the surface of the tiles, contains seldom any other impurities than a minute portion of sulphate of lime, and a small quantity of earthy matter mechanically suspended. The latter may be moved by immediate filtration, and the former by carefully adding to it barytic water. This will remove the sulphuric acid, and fall down with it as an insoluble precipitate; the lime which remains partly dissolved afterwards likewise falls down, by absorbing carbonic acid gas from the atmosphere; or it may be precipitated, by adding to the water a portion of water

impregnated with carbonic acid gas, and which will also destroy any excess of barytic water, if part should have been added in excess. In this manner the water necessary for chemical experiments may be economically supplied, without much trouble, and almost at no expense.

Barytic water soon spoils by the frequent opening of the bottle containing it; but it may be readily prepared, by dissolving a small quantity of barytic earth, or hydrate of barytes, in distilled water.

XLIV. MURIATE OF BARYTES.

This salt is extremely well adapted for discovering the presence of sulphuric acid, either when in a disengaged state, or when combined with other substances. It produces with sulphuric acid (like barytic water) a white precipitate, which requires for its solution 43,000 times its weight of water, and which is also perfectly insoluble in all acids, except the most concentrated; hence the precipitate obtained by this test may be collected, washed, and dried, with the greatest facility, and without risk of loss; it is free from smell and taste, and undergoes no change by being heated red hot, without addition, except the loss of water which it may contain. In a very strong fire, or before the blowpipe flame, it melts into an opake milky globule. From the quantity of the precipitate produced by this re-agent, we may learn the quantity of sulphuric acid which the test has separated from the solution; for 100 parts of the precipi-

tate, after being calcined, contain very nearly two-thirds of barytes, and one-third of acid, or 66.6 per cent. of the former, and 33.3 of the latter. Dr. Wollaston assumes 66 parts of barytes, and 34 of sulphuric acid; Berzelius, 65.69 of barytes, and 34.31 of acid. This test, which forms one of the most important instruments in analysis, is also decomposed (like barytic water) by carbonated alcalies; but the precipitate is then soluble in dilute muriatic or nitric acid; and may be prevented, by adding to the solution to be assayed a few drops of muriatic acid. Or if any excess of alcali has produced a precipitate of carbonate and sulphate of barytes, the two precipitates may easily be separated, by mere digestion in dilute muriatic acid, which removes the carbonate of barytes, and does not touch the sulphate. Concentrated nitric acid also decomposes a concentrated solution of muriate of barytes; the precipitate is crystallized nitrate of barytes; this is owing to the more sparing solubility of the nitrate, than of the muriate of barytes in water. Hence, in this case, the precipitate is soluble in water, by which it may be easily distinguished from sulphate and carbonate of barytes. This decomposition of muriate of barytes was first noticed by Mr. Hume. It may serve to guard the young chemist against drawing false conclusions, particularly with regard to the examination of the purity of nitric acid, when examined by means of this test.

EXPERIMENT CLVI.

Fill two test tubes with distilled water, and let fall into one of them a drop of sulphuric acid, and into the other a few drops of muriate of barytes; no change will take place in either of them; but if only a little of the fluid containing the muriate of barytes be poured into the liquid containing the sulphuric acid, a copious white precipitate (sulphate of barytes) will take place, which will not become re-dissolved by the admixture of dilute muriatic or nitric acid.

EXPERIMENT CLVII.

Put a grain of sulphate of soda (glauber's salts) into half a wine glass full of distilled water, and, when dissolved, add to the solution a few drops of muriate of barytes. The same appearance will be perceived as in Experiment CLVI.

A like effect will take place, if the liquid holds alum, epsom salt, white vitriol, or any other sulphate, in solution.

EXPERIMENT CLVIII.

Dissolve a few grains of sub-carbonate of potash in a wine glass full of distilled water, and pour half the solution into another glass. Drop into one of the glasses a little muriate of barytes, a white precipitate will fall down (carbonate of barytes) which again disappears by the admixture of pure dilute muriatic or nitric acid. Drop into the other glass pure nitric

or muriatic acid, in sufficient quantity to saturate the sub-carbonate of potash which it contains, and then add to the mixture also muriate of barytes, which now will produce a precipitate, which is perfectly insoluble in muriatic and nitric acid, because the free alcali being neutralized by the nitric acid, the precipitate produced by the test can only be occasioned by the presence of sulphuric acid.

XLV. ACETATE OF BARYTES.

This salt of barytes, the action of which as a test is similar to the preceding re-agent, is particularly well adapted for ascertaining the presence of sulphuric acid, when contained in vinegar, and in sulphureous acid. And although it may produce a white precipitate with genuine vinegar, on account of the malic, citric, or tartaric acid, which this fluid may contain, either in a free state, or combined with an alcaline base; but the precipitate then produced may be discriminated from the precipitate produced by sulphuric acid, by merely exposing it to heat, in order to destroy the vegetable acid, so as to convert it into a sub-carbonated alcali. This being done, the residue will dissolve and effervesce with dilute acids. Whereas the precipitate produced by sulphuric acid, when similarly treated, remains virtually insoluble in dilute acids. This test may likewise be employed, with advantage, for readily ascertaining both the nature and quantity of alcalies and alcaline sulphates in fluids, when no other sulphates are present, in the manner to be stated presently.

EXPERIMENT CLIX.

Add to vinegar a few drops of acetate of barytes; a copious white precipitate will fall down; collect this precipitate, dry it, and expose it to the heat of the blowpipe flame on a slip of platina foil, till all the carbonaceous matter is burnt away, and the product has assumed a white or grey colour. Transfer the mass; this is chiefly subcarbonate of potash, into a test tube, and pour upon it dilute muriatic or nitric acid; this will instantly dissolve it with an effervescence, which therefore shows that the vinegar was free from sulphuric acid.

EXPERIMENT CLX.

Repeat the same experiment with a portion of vinegar, to which a drop of sulphuric acid has been added. The precipitate obtained in this case, which is sulphate of barytes, after having been treated in the same manner with the blowpipe flame, will not be soluble in any dilute acid.

EXPERIMENT CLXI.

Dissolve a little sulphate of soda, or sulphate of potash, in distilled water, and pour into the solution acetate of barytes, a precipitate will take place, (which is sulphate of barytes) decant the supernatant fluid, evaporate it to dryness, and digest the residuum in alcohol; it will dissolve. Evaporate the solution to dryness again, and the dry salt will deliquesce, if it be acetate of potash; but effloresce, if it be acetate

of soda; 176 grains of ignited sulphate of barytes indicate 100 of dry sulphate of soda; while 136.36 grains of sulphate of barytes indicate 100 grains of dry sulphate of potash. The two alcalies, viz. potash and soda, may thus be discriminated. See also muriate of platina, p. 106, and tartareous acid, p. 63.

XLVI. NITRATE OF BARYTES.

This is another salt of barytes, which acts in every respect like the combination of barytes with muriatic acid. Instances, however, frequently occur in analytical operations, where the introduction of muriatic acid into the compound would render the analysis embarrassing; and in such cases, nitrate of barytes is employed more successfully. It is of particular use, also, to discover the alcalies, namely, potash or soda, when in fossils, and to ascertain their quantities. See *Manual of Analytical Mineralogy, intended to facilitate the Analysis of minerals, by F. Accum, vol.* II. *p.* 365.

XLVII. MURIATE OF ALUMINE.

This test has been recommended, by Mr. Kirwan, as indicative of carbonate of magnesia, when present in mineral waters, and which cannot, like carbonate of lime, be totally separated by ebullition, but remains till the whole liquid is evaporated. By adding muriate of alumine to the boiled water, a precipitate of carbonate of alumine is thrown down, if carbonate of magnesia be present; but not otherwise, unless

there be an excess of alcali, which may easily be neutralized by an acid.

XLVIII. SUCCINATE OF AMMONIA.

This test is recommended, by Klaproth, as an useful re-agent for detecting iron, and for readily ascertaining its quantity when in a solution; the iron, however, must be in the highest state of oxidation; and in applying this test, it is necessary not to use more than is exactly sufficient for the purpose, because an excess is liable to re-act on the precipitate. It produces with iron a brown precipitate. It is very useful to separate oxide of iron from oxide of manganese.

EXPERIMENT CLXII.

Put a few grains of green sulphate of iron into a test tube; pour upon it five or six drops of nitric acid, and heat the mixture strongly over a lamp till a dry red mass is obtained. Re-dissolve this mass in distilled water; and, having filtered it, drop into it succinate of ammonia. The iron contained in the sulphate of iron, having become highly oxigenized by the action of the nitric acid, a brown flocculent precipitate (succinate of iron) will be obtained. This precipitate, when heated, first by itself, and afterwards with a little wax, at a low red heat, gives an oxide of iron, containing 70.5 per ent. of metal.—The first heating decomposes the succinic acid, and the second reduces the metal to the state of a black oxide.

This succinate, however, precipitates also alumine, provided there be no considerable excess of acid in the aluminous solution.

XLIX. SOLUTION OF STARCH.

A solution of starch in water has of late received a place among the list of chemical re-agents, as a test for detecting iodine. Its action, as such, was first made known by professor Strohmeyer, of Gottingen. If a solution of starch be added to a liquid, containing a very minute quantity of iodine in an uncombined state, it produces, with it, an indigo blue colour, and a precipitate (ioduret of starch) of the same hue is slowly precipitated. The delicacy of this test is astonishingly great. It will indicate (according to Strohmeyer) 1-450,000th part of iodine in a liquid. Hence iodine and starch are tests for each other, and have been successfully employed as such, by M. de Claubray, who detected, by means of starch, not only the presence of iodine, in the decoctions of the *fucus saccharinus*, but also its state of existence, or the manner in which this singular substance is combined, in the body of the several varieties of sea plants which have furnished it. The blue colour, produced by the contact of iodine and dissolved starch, varies, according as either the one or the other of the substances predominates. When the two bodies are in due proportion, the colour is a pure intense indigo blue; but it is black, when iodine prevails, and of a reddish blue or violet colour, when starch is in

excess. When iodine is not present in the fluid, in a free or uncombined state, it is necessary to add to the solution a very minute portion of any acid, in order to disengage the iodine from its combination. Hence, if a solution of starch be dropt into a fluid containing hydriodic acid, or iodic acid, no change takes place; but if an acid be added, so as to disengage the iodine, the starch then instantly shows the presence of this substance, by the indigo blue colour which it assumes.

The compound of starch and iodine, or ioduret of starch, is soluble in dilute sulphuric acid, and the liquor is of a fine blue colour; and, with concentrated sulphuric acid, a brown compound is obtained, which becomes also blue when diluted with water.

L. SULPHATE OF SODA.

Sulphate of soda, or sulphate of potash, may be employed for detecting the presence of lead, by virtue of one of the constituent parts of this salt; namely, the sulphuric acid, combining with the oxide of lead, and forming with it a white precipitate (sulphate of lead) which is insoluble in water, and in liquid ammonia, but soluble in dilute nitric acid, when assisted by heat; and which becomes blackened by water impregnated with sulphuretted hydrogen gas. These characters are sufficient to distinguish it, at once, from sulphate of barytes, with which it might otherwise be confounded; because, from what has been stated (page 156) this test must also produce a

white precipitate with all the salts of barytes and of strontia. Sulphate of soda, or sulphate of potash, is chiefly of use in such cases, where sulphuric acid, in an uncombined state, cannot be well applied, as is often the case in the analysis of mineral waters. Dr. T. Thomson considers this test "as the most unequivocal re-agent of lead which we possess;" for, by means of it, he was enabled to detect in water the *one millionth* part of its weight of lead. (*See Analysis of the mineral waters of Tunbridge Wells, by* Dr. SCUDAMORE, p. 57. 1816.)

EXPERIMENT CLXIII.

Let fall into a test tube full of distilled water a drop of super-acetate of lead, and add to the mixture a few drops of a solution of sulphate of soda, or sulphate of potash; a dense white precipitate will fall down, which is sulphate of lead. Decant the supernatant fluid, pour upon the precipitate dilute nitric acid, and apply a gentle heat. The precipitate will again become re-dissolved. If water impregnated with sulphuretted hydrogen be added to it, it will become instantly blackened.

LI. CARBONATE OF AMMONIA

Is made use of in combination with phosphate of soda, for detecting and separating magnesia (see p. 88) from other earths, when combined with them in solutions. It is also employed for separating yttria, and glucine, from other earths; both of which are solu-

ble in a solution of this salt. Copper is detected by this re-agent, by imparting to the fluid containing this metal a sapphire blue colour, (see page 131) and like the rest of the carbonated alcalies, it precipitates the solutions of earthy and metallic salts, and from the colour of this precipitate, the experienced operator may in some cases form a notion of the nature of the precipitate obtained by means of this test.

LII. FLUATE OF AMMONIA.

This salt has been recommended as a test for lime, with which it produces a white precipitate (fluate of lime.) But it is not discriminative, because it affects also the salts with a base of magnesia, yttria, glucine, and perhaps alumine; its action upon the whole is much inferior to oxalate of ammonia, (page 138.)

LIII. ALCOHOL.

Highly rectified alcohol is of particular use in the analysis of mineral waters. When added to a liquid in large quantities, it precipitates such saline bodies as are soluble in water and insoluble in alcohol. It is essential, however, that the saline fluid should be as concentrated as possible, and the quantity of alcohol added should be, at least, double that of the bulk of the fluid on which it is intended to act. Thus sulphate of lime, or selenite, may be precipitated, by alcohol, from water, which contains this salt in the proportion of 1-1000, provided the specific gravity

of the alcohol is below .850. And alcaline sulphates may be precipitated, if the spirit is of a specific gravity equal to .817. Besides, as alcohol dissolves some of the substances often found in mineral waters, and does not touch others, it enables us to separate these into two classes. Alcohol is also employed for de tecting the adulterations of essential oils.

EXPERIMENT CLXIV.

Dissolve 30 or 40 grains of sulphate of magnesia in 1-4 or 1-2 oz. of distilled water; put the solution into a test tube, and add to it two or three times its bulk of alcohol. The mixture will become turbid and by degrees minute crystals of sulphate of magnesia will be deposited at the bottom of the glass. If, instead of sulphate of magnesia, sulphate of soda, sulphate of potash, super-sulphate of alumine, or nitrate of potash, be employed, the same effect will take place.

EXPERIMENT CLXV.

Mix about five grains of acetate of potash with any quantity of sulphate of potash; put the mixture into a phial furnished with a stopper, and, after pouring some alcohol upon it, set the mixture in a warm place to digest for 24 hours. Decant the fluid from the insoluble residue, and evaporate it to dryness. The product will be the acetate of potash which was added to the spirit; but the sulphate of potash will

not have been touched. In a similar manner different substances may frequently be separated from each other, by the mere action of alcohol.

Thus the greatest number of mineral waters contain some earthy salts, with a fixed acid, which remains in combination after boiling down the water to dryness, and which acid is seldom any other than the sulphuric and muriatic; and the earths, with which the acid is combined, are in general either lime or magnesia. Therefore only four earthy salts may be expected (not all together at once, for they would decompose each other) namely, sulphate of lime, muriate of lime, sulphate of magnesia, and muriate of magnesia. Now of these salts the sulphates are perfectly insoluble in alcohol, but the muriates are extremely soluble. This therefore affords a very convenient way of separating some of the salts. For this purpose, if we put the dry residue of the water in a phial, pour on it about five or six parts of alcohol, and let the mixture remain for some hours, with frequent agitation, the alcoholic solution can contain only the muriates of lime and magnesia, provided the alcohol has been highly rectified; if not, it will also dissolve a little muriate of soda, if present. The residue, which is not dissolved by the alcohol, may contain the sulphates of lime and magnesia, of which the latter salt is easily soluble in water, but the former with great difficulty, unless assisted by an acid.

EXPERIMENT CLXVI.

As many of the volatile or essential oils are produced but in small quantity, they are consequently high priced, and there is some temptation to adulterate them with fixed oils, to increase the quantity. It is therefore of considerable importance to be able to detect such frauds, which may be done in the following manner:—Mix a few drops of oil of almonds, or olives, with any essential oil; for instance, with oil of lavender, and pour alcohol upon it. The oil of lavender will dissolve in the spirit, and the oil of almonds remain behind undissolved. Decant the alcoholic solution from the oil of almonds, and add distilled water to the former; the water will unite with the alcohol, and by this means the essential oil of lavender will be separated. An additional examination may be the following: let a single drop of the oil which is suspected fall on clean paper, and expose it to a gentle heat. If the oil be pure, the whole will become evaporated, and no trace or spot remain on the paper; but if it has been mixed with a fixed oil, a greasy spot will remain behind. When essential, or volatile, oils are adulterated with alcohol, it is easily detected by mixing a little of the oi with water, which immediately produces a milkiness, by the abstraction of the alcohol from the oil, and its combination with the water. Volatile oils are frequently adulterated with oil of turpentine; but this can only be detected by the peculiar odour of oil of

turpentine, which continues for a longer time than the odour of the other volatile oils.

LIV. SOLUTION OF SOAP.

A solution of soap in alcohol is of some use as a test for ascertaining, what is vulgarly called, the *hardness* of waters; because, when added to pure water, it produces no change, but when dropped into water loaded with earthy or metallic salts, it occasions a milkiness, and a flocculent precipitate is formed. And from the degree of milkiness, and the quantity of the precipitate produced, some notion may be formed of the quality of the water, at least so far as regards its fitness for the purposes of washing, dying, bleaching, boiling leguminous and cereal seeds, and other purposes of the culinary art and domestic economy, for which water as pure as possible ought to be employed.

EXPERIMENT CLXVII.

Into a test tube half filled with distilled water, pour a few drops of a solution of soap in spirit of wine, and no alteration will be produced.

EXPERIMENT CLXVIII.

To a like quantity of common pump or spring water add a few drops of solution of soap: a milkiness will instantly ensue, and a flaky precipitate will be deposited, if the mixture be left undisturbed for some hours. The milkiness is owing to the presence

of earthy salts, which in pump water are usually sulphate and carbonate of lime; the alcali of the soap leaves the oil, with which it was chemically combined, and unites with the acid of the earthy bases of the salts which are present in the water: and the oil joins the earth, and produces with it an insoluble precipitate, or earthy soap.

The action of this test is therefore not discriminative, and it can serve only to indicate the presence or absence of those kinds of substances, which occasion that quality in water which is usually called *hardness*, and which is chiefly owing to salts with an earthy or metallic base.

EXPERIMENT CLXIX.

Having impregnated a small quantity of distilled water with carbonic acid gas, dissolve in it a few grains of white marble, or magnesia, and after the liquid is poured off clear from the insoluble residue, add to it a few drops of the solution of soap, and in like manner a white curdy precipitate will be produced.

EXPERIMENT CLXX.

Dissolve a few grains of sulphate of magnesia, or muriate of lime, or of alum, in half a wine glass full of distilled water, and add to the mixture a few drops of the solution of soap; the fluid will become milky, and deposit a white flocculent precipitate.

The same effect will be produced with any other earthy or metallic salt.

EXPERIMENT CLXXI.

Mix a drop of a solution of sulphate of iron, or any other metallic salt, with half a wine glass full of distilled water, and add to it a few drops of a solution of soap; this will in like manner become turbid, and a great number of flakes will be deposited.

LV. WINE TEST.

This test is nothing else but water impregnated with sulphuretted hydrogen gas, combined with a small portion of muriatic, or any other weak acid. It is employed chiefly for readily distinguishing iron from lead in wine. By adding this test to wine, or any other liquid suspected to contain lead, the liquor, if iron only be present, will remain transparent, and no precipitate will be formed; but if it contains the minutest portion of lead, the test will occasion a black muddy precipitate (which is sulphuret of lead;) because the weak acid, combined with the sulphuretted hydrogen, is not capable of dissolving sulphuret of lead; and this precipitate, when fused before the blowpipe with a minute portion of lime or fine iron filings on a charcoal support, then yields a globule of metallic lead. This test, however, is not discriminative; because iron dissolved in acetic, or in any other vegetable acid, is also precipitated by it. It likewise yields a black precipitate, with solutions of iron in general, provided a minute portion of acetate of potash be added to the fluid, prior to the addition of the test liquor.

LVI. ZINC.

Metallic zinc is chiefly employed as a re-agent for separating copper, lead, tin, silver, and tellurium in a metallic state, from their solutions in acids. It also precipitates lead, tin, copper, and tungsten, from their alcaline solutions; but it is seldom employed for that purpose, because, we have better means (acids) of effecting the decomposition of these solutions.

When zinc (and in fact any metal) is employed to separate another metal, in a metallic form, from its solution in an acid, it is essential that the fluid should have a very slight excess of free acid; for otherwise, a portion of the metal is thrown down, either in the state of an oxide or as an alloy.

EXPERIMENT CLXXII.

Add to a wine glass full of distilled water a small quantity of the solution of super-acetate of lead, mixed with a few drops of acetic or nitric acid, and immerse into the fluid a slip or a piece of zinc. The lead contained in the solution will immediately become precipitated upon the zinc, in the form of a metallic and moss-like appearance, and of a dark bluish grey colour.

EXPERIMENT CLXXIII.

The precipitation of lead, which has been long known by the name of the *lead tree*, may be here

mentioned. It is accomplished in the following manner:—Into a quart decanter, nearly filled with soft or rain water, put 3-4 oz. of super-acetate of lead, (sugar of lead of commerce) reduced to powder; shake the mixture, and suffer it to stand undisturbed for two or three days; then decant the clear fluid from the insoluble residue (if any;) reject the latter, and after having rinced the decanter with water, return into it the clear solution. If now a ball of zinc be suspended in the middle of the fluid, by tying it to a thread affixed to the stopper of the bottle, and the vessel be then set in a place where it cannot be disturbed, the zinc soon becomes covered with a moss-like substance of metallic lead, which increases gradually, and shoots out brilliant crystalline plates of metallic lead, which place themselves in a kind of symmetrical arrangement, somewhat resembling a tree or shrub.

The zinc has a greater affinity than lead for oxigen; it deprives the oxide of lead of it, which, being thus reduced to the metallic state, can no longer remain in combination with the acetic acid, but becomes precipitated upon the zinc. The theory of voltaic electricity has of late shown that this phenomenon, (like all other metallic precipitations,) is the result of a voltaic action produced between the bodies brought into contact. Namely, when the precipitation of the metallic lead takes place on the surface of the zinc, voltaic electricity is evolved, in consequence of an easily oxidable metal coming into con-

tact, together with a fluid, with another metal, which is with more difficult oxidizable. A galvanic circle being thus formed, part of the water of the interposed fluid becomes decomposed; one of its constituent parts, namely, the oxigen, becomes attracted by the metal positively electrified (the zinc) whilst its other constituent part, the hydrogen, is attracted by the metal negatively electrified, namely, the lead; it there acts in producing the further reduction, by abstracting oxigen from the metallic oxide dissolved in the acid, and the particles of the reduced metal are gradually deposited at that extremity; and the accretion of the metallic crystals taking place from the metallic filaments already formed, spread out and arrange themselves somewhat like a shrub or tree.

The theory of the reduction of other metallic precipitates from their solutions is precisely analogous to this statement.

EXPERIMENT CLXXIV.

Immerse a bar, or a slip of laminated zinc, into a dilute solution of sulphate of copper, having an excess of acid; a precipitation of metallic copper will immediately take place, and the zinc will become incrusted with a coat of copper. The copper may readily be detached from the zinc; it is advisable to digest it in muriatic acid, which will dissolve any zinc, if part of it should happen to adhere to the copper; and besides, unless there is a considerable excess of

acid in the solution, a portion of the copper is always precipitated as an oxide, and which is thus completely removed by the muriatic acid.

EXPERIMENT CLXXV.

Add to half a wine glass full of distilled water 8 or 10 grains of sub-muriate of tin, and immerse into this fluid a slip of zinc; the tin will immediately become precipitated in a metallic state, surrounding the zinc in the form of a spangled moss-like coating.

Mr. Silvester has recommended a galvanic circle, formed of zinc and gold, as an active agent for detecting corrosive sublimate, if applied in the following manner.

EXPERIMENT CLXXVI.

Let a piece of zinc wire, about three inches long, be twice bent at right angles, so as to resemble the Greek letter ⊓, so that the two legs of this figure be distant about the diameter of a common wedding ring from each other, and let the two ends of the bent wire be afterwards tied to a ring of this description. Then take a plate of glass, not less than three inches square; lay it as nearly horizontal as possible, and on one side drop some sulphuric acid, diluted with about six times its weight of water, till it spreads to the size of a halfpenny. At a little distance from this, towards the other side, drop some of the solution, supposed to contain corrosive sublimate, till the edges of the two liquids join together,

and let the wire and ring, arranged as above stated, be placed in such a way that the wire may touch the acid, while the gold ring is in contact with the suspected liquid. If the minutest quantity of corrosive sublimate be present in the fluid, the ring in a few minutes will then become covered with metallic mercury, on the part which touches the liquid. In this manner the minutest quantity of mercury may be discovered, when present in any liquid.

LVII. IRON.

Polished iron wires, bars, or plates, are useful reagents for precipitating copper in a metallic state from its solution in acids. Iron likewise precipitates antimony and tellurium in a metallic form from acid solutions.

EXPERIMENT CLXXVII.

Immerse the blade of a knife, a key, or any other piece of polished iron or steel, for a few seconds, into a solution of sulphate of copper, having a slight excess of sulphuric acid; the knife, when withdrawn, will be covered with a coat of metallic copper. To obtain the copper in a pure state, the precipitated metal ought to be digested in dilute muriatic acid.

LVIII. TIN.

This metal is useful as a test for detecting the presence of gold, with the solutions of which it produces a purple coloured precipitate. If a slip, or a

bar of tin, be immersed into a solution of muriate of gold, the surface of the tin becomes immediately covered with a deep purple coloured powder, which becomes gradually diffused through the whole fluid, and imparts to it the colour of red wine. The powder thus produced speedily subsides, and leaves the solution of gold colourless. This powder is similar to the precipitate produced by sub-muriate of tin, and muriate of gold. See sub-muriate of tin, p. 129.

EXPERIMENT CLXXVIII.

Add to half a test tube full of distilled water a few drops of muriate of gold, and immerse into it a piece of tin, or a tin-wire. In a short time a violet or purple coloured precipitate will fall down; which is a compound of gold and oxide of tin. See page 129.

LIX. COPPER

Is used in analytical experiments, chiefly as an agent for separating silver in a metallic state from its solutions. When a bar or rod of this metal is immersed in a solution of silver in an acid, it becomes superficially of a blackish colour, and after a while the silver is precipitated upon the copper in a metallic state. The whole of the silver is not however separated by the copper, for the solution becomes milky, on adding to it common salt or muriatic acid. Still it is a very convenient way of reco-

vering the silver immediately in the metallic state. If the solution has no considerable excess of acid, the latter portion of silver, thus precipitated, contains a minute portion of copper; but this may be prevented, by adding to the fluid a slight excess of nitric acid, or bringing the precipitate again into contact with a solution of nitrate of silver.

This process is followed in the art of *assaying*, to recover the silver which has been alloyed with gold, and which, in the operation of *parting*, has been dissolved by nitric acid; plates of copper being put into the solution, so as to precipitate the silver. It is also frequently employed to obtain silver free from other metals with which it has been alloyed.

EXPERIMENT CLXXIX.

Add to half a wine glass full of distilled water five or ten drops of the solution of nitrate of silver, and immerse into it a bar or slip of copper. The silver will immediately be precipitated upon the surface of the copper in a brilliant metallic form.

This experiment may be pleasingly varied in the following manner.

EXPERIMENT CLXXX.

Spread on a plate of glass a few drops of nitrate of silver diluted with double its quantity of distilled water; place at the bottom of it, flat upon the glass, and in contact with the fluid, a copper wire, bent to any figure, and let the whole remain undisturbed in

an horizontal position. In a few hours a crystallization of metallic silver will make its appearance upon the glass next the piece of copper wire, and the arrangement of crystals will extend gradually, till the whole quantity of fluid is decomposed.

LX. QUICKSILVER, AND SILVER LEAF.

Both these metals are useful for discovering minute portions of sulphuretted hydrogen gas, or sulphurets in general, particularly when contained in mineral waters; because the metallic brilliancy of these metals becomes destroyed, when they are suffered to be immersed in a fluid containing sulphur in a loose combination.

EXPERIMENT CLXXXI.

Fill a phial with water impregnated with sulphuretted hydrogen gas, and add to it a few globules of mercury, free from dust, or a silver leaf; in a short time the metal will lose its metallic splendor; and its surface will become covered with a brown pellicle, which is a combination of sulphur with the metal.

LXI. FLUXES FOR THE BLOWPIPE.

The term flux is applied in chemistry to those substances which are added to minerals, metallic ores, or other bodies, to assist their fusion when exposed to the action of fire. Thus potash or soda, in a pure state, or as sub-carbonates, are fluxes for flint, and all kinds of siliceous minerals; because, when flint is mixed with these bodies in a proper

proportion, and heated, these alcalies cause it to melt, and the compound is a vitreous mass ; and boracic acid and borax are fluxes for clay and argillaceous minerals, &c. These bodies therefore act upon refractory substances in the *dry way*, as water, acids, and other liquids act (which are used to dissolve solids) in the *humid way*. The manner in which each mineral is affected when it is heated with different fluxes, its fusion, more or less quick or slow, easy or difficult, or complete or incomplete, liquid or pasty, the kind of mass which results from it, opake, transparent, vitreous or enamelled, scorified, or dense and compact, the colour which it principally affects, and which almost always depends on the nature and the proportion of the metallic matters which it contains—these form so many useful characters, employed by analytical mineralogists to discover and distinguish each species of the several compounds ; and when the external characters or the sensible properties do not suffice to determine with accuracy the kind or species, this action of the fluxes employed with the blowpipe is frequently very useful to that determination, by removing doubts, destroying uncertainties, and explaining the general nature of the mineral.

It may easily be imagined that the nature of the products will greatly vary, according to that of the flux which enters into combination with them : and, accordingly, fluxes are varied in experiments according to the object in view.

The fluxes which are used for the blowpipe experiments, and in all the laboratory operations in general, are chiefly compound bodies belonging to the class of salts. One of the constituent parts of these bodies frequently acts chemically: thus the alcaline and earthy part of fluxes often combines with the acid which may be attached to a metallic oxide, and which would prevent its reduction to the metallic state, if not separated; whilst others again act merely mechanically. And further, many of the metals will retain their oxigen so forcibly, that the application of heat is totally incapable of expelling it, when the object is to obtain the metal. The addition of inflammable matter becomes therefore expedient, to carry off the oxigen in the form of gas. The oxide to be reduced is therefore mixed with a portion of inflammable matter; and is then exposed to an intense heat; and to obtain the reduced metal in a coherent mass, and not in small grains, a substance must be also present, which is capable of being readily melted, and of allowing the metal to subside through it, so as to cause the particles to conglomerate and to form a collected button, instead of scattered grains, which would otherwise happen. And it would be extremely laborious to collect together the minute particles, if they were not thus enabled to descend, and permitted to unite at the bottom of the crucible. The action of fluxes are, therefore, in general, both mechanical and chemical.

The fluxes which have obtained the general sanction of chemists, on account of their extensive use, are, phosphate of soda (page 88) sub-borate of soda (page 129) and boracic acid (page 66) besides these, fluor spar, gypsum, sub-carbonate of soda, nitrate of potash, and glass, are occasionally employed in the blowpipe assay. These bodies are reduced to powder, and mixed up with the substances upon which they are to act. See pages 66, 88, 129. What is called *white flux* is a mixture of a little potash with carbonate of potash, and is prepared by deflagrating together equal parts of nitrate of potash and supertartrate of potash. When an oxide is at the same time to be reduced, the flux called *black* flux is to be preferred, which is produced by the deflagration of two parts of supertartrate of potash, and one of nitrate of potash. It differs from the former only in containing a little charcoal. Soap likewise promotes fusion, by being converted by the fire into carbonate of soda and charcoal, and therefore also acts as a flux, and is frequently employed as such in the laboratory.

LXII. BLOWPIPE,

AND

ITS APPLICATION.

The blowpipe, in chemistry and mineralogy, is an instrument of the greatest utility. It enables us to

expose to the action of a most violent heat, any substance we may meet with, in order to ascertain its general nature or qualities with regard to fire: every effect of the most intense heat of furnaces may instantly be produced by this instrument; and with this advantage, that the process is expeditious, and under the inspection of the operator; whereas we can only conjecture what passes in the centre of a furnace, if the same experiment be made in the laboratory way. The most expensive materials, and the minutest quantity of bodies, may be used, and the whole process, instead of being carried on in an opake vessel, may instantly be varied under the eye of the observer, and may be seen from beginning to end. Indeed, many advantages may thus be derived from the use of this simple and valuable instrument. Its smallness, which renders it suitable to the pocket, is no inconsiderable recommendation to the travelling mineralogist. It is true, that very little can be determined in these miniature assays concerning the actual quantity of products; but in most cases, a knowledge of the contents of any mineral substance is a great acquisition, which is thus obtained in a very short time, although the actual quantities of the products discovered are too minute, to enable the operator to ascertain their relative proportions.

Thus, for example, if we meet with a species of clay, and wish to know whether it be fit or not for the purpose of making porcelain, the blowpipe assay will decide the question. Because, for the purpose

of making the finer kinds of pottery and porcelain, it is essential to have a clay, which, *after burning*, remains perfectly white. The appearance of these substances, before burning, can never be depended on: for though often the whitest clays, before burning, are those which remain white afterwards, it is only in a few districts where clays are found that remain absolutely white. And many white clays are to be found, which, when burnt, become more or less coloured, and again many black clays burn perfectly white. The nature of *lime stone* may readily be discriminated by means of this instrument. Lime stone, fit for making mortar and cement, does not melt by itself, but becomes more or less white after being violently heated by the blowpipe flame, and if suffered to cool, and then mixed with water, becomes hot. This proof is best made by putting the minute portion of the assayed stone on the outside of the hand, and letting fall on it a drop of water, when a quick heat will be felt on the skin. *Silicious stones* never melt alone, but form a glass with borax and soda; argillaceous stones, when pure, do not melt, but become white, and acquire a flinty hardness. Fluor spar becomes phosphorescent, and melts into an opake white slag; zeolites melt easily, and foam in the flame.

And from the colour which the substances called fluxes acquire, much useful information may be drawn concerning the nature of the mineral under ex-

amination. Thus, for example, gold imparts to borax, and phosphate of soda, and boracic acid, a ruby colour. Silver tinges these fluxes orange yellow; copper produces with the same fluxes a bluish green pearl; iron tinges them green, of different intensities and hues; tin produces a white, or greyish white opake enamel; antimony affords a hyacinth coloured glass, and flies off partly in white fumes, and a white powder, or oxide of antimony, is deposited on the surface held near the fixed substance. Arsenic likewise diffuses white fumes, when heated on charcoal, and produces a garlic like odour; cobalt stains a large quantity of borax intensely blue, and forms with it a blue glass. Oxide of manganese yields with the inner point, or the blue flame, a violet coloured head, which, with the interior part of the flame, become again colourless, and which may be made alternately to disappear and re-appear at pleasure. These successive changes of colour, which are peculiar to the oxide of manganese, may be shewn in the following manner.

EXPERIMENT CLXXXII.

Melt a small quantity of phosphate of soda, or glass of borax, with the blowpipe flame, upon a piece of charcoal, and add to it a very small portion of black oxide of manganese (melt the mixture together by the inner blue flame) the globule will assume a violet or purple colour. Then fuse it again, and

keep it in a melted state for a longer time, the effects of which will be, that the violet colour again vanishes. This being effected, melt the colourless globule by the exterior flame of the blowpipe, and the purple colour will re-appear, but becomes, as before, again destroyed by a longer continuance of the heat. The smallest particle of nitre laid upon the globule also immediately restores the red colour. If the globule when colourless be now melted in a silver spoon, or on an iron plate, or any metallic support, instead of being on the charcoal, the violet colour returns, and will not be again removed by any continuance of heat, so long as it remains on the metallic support.

Some minerals, when exposed to the blowpipe dart, are perfectly infusible by it; others melt with facility; some are partly volatilized, others burn with a flame of a peculiar colour; in some the colour is changed at different temperatures, as in the oxide of manganese; some fuse with intumescence: others decrepitate, or exfoliate, when urged by the flame, or lose their colour; in some the fusion is partial; sometimes the result is a kind of ashes or powder; in many cases it is a complete vitrious globule, transparent, or opake, or of various colours. Some afford a mere scoria or cinder, others produce an enamel, and some give a mere *frit*. All these gradations of phenomena are so many means of discovering, and of estimating the differences particularly of earthy minerals, and they contribute also to the know-

ledge and the determination of the particular species of the individual which afford it.

It requires a little art to keep up an uninterrupted blast of the blowpipe with the mouth, which is not easily described, but may readily be acquired by practice. The act of breathing must be carried on through the nostrils without interruption, and the stress of blowing must be performed merely by the compression of the checks upon the air in the mouth. Beginners blow generally too strong, which obliges them to take breath very often. The whole art consists in inspiring the air through the nostrils, whilst the air contained in the mouth is forced out through the blowpipe, so that the action of the nostrils, lungs, and mouth, resemble the action of double bellows; and to accomplish this object, there is no necessity of blowing violently; but only with a moderate and equable force, and then the breath can never fail the operator. This art of blowing properly is by some acquired in an instant, while others are a long time in making themselves masters of it. To those who experience any difficulty in the free use of the blowpipe, the following directions may be of service. First, let the learner accustom himself to breathe freely with the mouth shut; then, in making an expiration, let him transfer the air into the mouth, till the cheeks are moderately inflated, and retaining it there, let him discharge the surplus of the expiration through the nostrils, and then make two or three ea-

sy inspirations and expirations through the nostrils, without allowing the air in the mouth to escape.—When practice has rendered this easy, which may be effected in half an hour, let the nozle with the smallest aperture be fixed on the jet tube of the blowpipe, and introduce the mouth piece within the lips; then inflate the cheeks by an expiration, and continue breathing easily through the nostrils, till nearly the whole of the air has passed out of the mouth through the tube; then renew the air as before, and, after a few days practice, the muscles of the mouth will be accustomed to this new mode of exertion, and an uniform uninterrupted stream of air may be kept up for half an hour without any extraordinary fatigue.

The best kind of flame for blowing through with the blowpipe is a thick wax or tallow candle, with a very large wick, which should be kept snuffed moderately low, and the wick turned a little aside from the pipe; the spirit lamp may also be used; it makes a perfectly clear flame without smoke, but weak in comparison to a thick wax candle; although a wax candle is the most convenient, a thick tallow candle will do very well. The candle should be snuffed rather short, and the wick turned on one side towards the object, so that a part of it does lie horizontal. The stream of air must be blown along the horizontal part as near as may be without striking the wick. If the flame be ragged and irregular, it is a proof that the hole of the blow-

pipe nozle is not round or smooth; and if the flame have a cavity through it, the aperture of the nozle pipe is too large. When the hole is of a proper figure, and duly proportioned, the flame consists of a neat luminous blue dart or cone, surrounded by another flame of a more faint and indistinct appearance. Too great a flame does not easily yield to the blast, and too small a one produces a weak effect.

In using the blowpipe, the following observations should be attended to. The end of the nozle pipe must be just entered into the flame, and the current of air will then throw out a cone or dart of flame from the opposite side. If it is well managed, this dart or cone will be very distinct and well defined. Care must be taken that the stream of air does not strike against any part of the wick, as it would then be disturbed, and split into several parts. The jet or blast of air must be delivered somewhat above the wick; and as, unless the flame was considerable, there will not be sufficient for the stream of air to act upon, for this reason the wick is best to be opened, because it then exposes the largest surface, and produces the greatest flame; the stream of air from the pipe should then be directed through the channel or opening between the wick, so as to produce a cone the most perfect and brilliant, directed downwards, at an angle of about 45 degrees.

Its intensity is different according to the different parts of the flame. The place where this intensity is

strongest is the extremity of the blue point of the flame.

Every substance intended to be assayed with the blowpipe should be heated very gradually, the flame should be directed very slowly towards it in the beginning, not directly upon it, but somewhat above it, and so approaching nearer and nearer with the flame, until it becomes red hot. Whenever any mineral substance is to be tried, we do not immediately begin with the blowpipe, because minerals are not always homogeneous, or of the same kind throughout, although they may appear to the eye to be so. A *Magnifier* is therefore necessary, to enable us to discover the heterogeneous particles, if there be any; and these ought to be separated, and every part tried by itself, that the effects of two different things, examined together, may not be attributed to one alone.

The substance upon which the flame acts ought to be proportioned to the size of the flame to which it is exposed. If the aperture of the blowpipe is only of the diameter of a common pin, the substance ought not to be larger than a pepper corn. In order to support the substance, it may be laid upon a piece of close-grained well-burned charcoal, made of elm or poplar wood. A small shallow hole may be scooped out with a knife on the piece of charcoal, and the substance laid upon it. The charcoal itself kindles all round the hole, and the hole is thus gradually enlarged; and the heat too is kept up round

the substance much more uniformly than when a metal support is used. At the same time, however, the chemical effect produced by ignited charcoal should not be forgotten, particularly in the reduction of metallic oxides, and the deoxygenation of the fixed acids; so that, for example, a small heap of oxide of copper, lead, or tin, heated red-hot on charcoal by the blowpipe, is speedily reduced to a metallic state; hence also fragments of tin stone, (tin ore) common lead ore, or galena, ruby copper, &c. are easily reduced, when heated on a charcoal support.

Very small and brittle substances are apt to be carried away by the current of flame from the piece of charcoal. These may be secured by making a deep cavity in the charcoal, into which the substance is to be put, and covered with another small piece of charcoal, which partly protects it from the flame.— Some experiments of reductions are best made by binding two flat pieces of charcoal together, cutting a channel along the piece intended to be uppermost, and making a cavity in the middle of this channel, to contain the matter to be examined. With this contrivance the flame may be urged through the channel between the two pieces of charcoal, and thus violently heats the substance in the cavity, which may be considered as in a closed furnace.

Those bodies upon which charcoal acts chemically (but when intended to be exposed to the blowpipe flame, without suffering such changes to take place,)

may be placed in a small spoon, somewhat less than a quarter of an inch in diameter, made of gold, silver, or platina. The spoon must of course be properly fixed into a wooden handle. Silver or gold spoons are best adapted for fusions with alcaline fluxes, for which those made of platina are entirely unfit; they have nevertheless the capital disadvantage, that they will only bear a dull red heat without risk of melting: whereas spoons of platina are perfectly infusible by the blowpipe flame.

A small forceps, entirely made of platina, is also very convenient and useful for easily exposing fragments of stones to the dart of the blowpipe; because these bodies may be held with them, and the forceps cannot be melted nor oxidated; nor does it become too hot to be held by the fingers during trial, on account of the bad conducting power of the metal of which it is fabricated. They are also convenient for handling or taking out from the melted fluxes the small bead of the product.

Flattened platina wire is another very useful article for exposing fragments of infusible substances to the action of the blowpipe flame. The fragment may easily be secured between a piece of the wire bent round it, and may thus be firmly held in any direction we chuse.

Platina foil is likewise very serviceable for exposing to the flame of the blowpipe such substances as

readily split, and are dispersed when heated by the blowpipe dart on charcoal, or when held by the forceps or placed in the spoon, or when secured between platina wire. Any substance, wrapped up in a piece of this foil, may readily be kept steady during trial, and hence it is best adapted for pulverulent substances. Slender filaments of cyanite or of asbestos may also be employed occasionally.

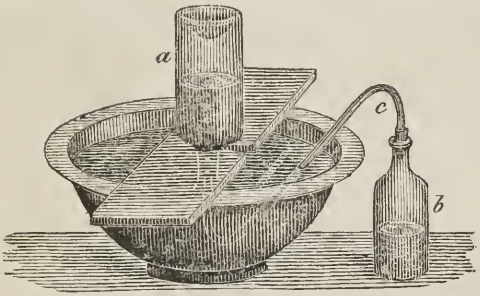
The best blowpipe for chemical and mineralogical purposes is the so called *Pocket Blowpipe*, invented by Mr. Pepys, which is sufficiently known, and does not require to be described.

LXIII. WATER IMPREGNATED WITH CARBONIC ACID GAS,

OR

LIQUID CARBONIC ACID.

As water impregnated with carbonic acid gas is one of the articles requisite for the performance of several of the experimenss exhibited in this treatise, (*see pages* 31, 33, 36, 40, 41, 46, 47, 48, 53, 92, 140, 153,) and as this article cannot be readily procured on all occasions, we shall give a description of an *extemporaneous* apparatus, by which means this fluid may easily be prepared.

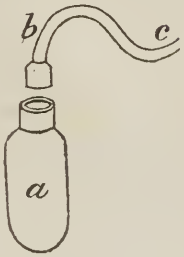


It consists of a common earthen ware basin (a wash-hand basin) across the rim of which is placed a wooden board, four or five inches wide, and about 3-4 of an inch thick, having a slit, terminating in a hole, cut in the centre of the board, which hole serves to receive the inverted common quart bottle *a*, as shown in the drawing. *b* is a similar bottle, furnished with a bent glass tube *c*, which connects the two bottles, and serves to convey the gas from the bottle *a* to *b*; for one extremity of this tube passes air tight through the cork in the neck of the bottle *b*, whilst the other end is inserted into the neck of the inverted bottle *a*. To impregnate water with carbonic acid gas, (or with any other gas which is not absorbable by water) by means of this apparatus; let the bottle *a* be filled with water, quite full, stop it with a cork, and invert it with its neck downward into the earthenware basin, also previously filled with water, and let it rest in the centre hole of the board, as represented in the design, and then withdraw the cork. This being done, put some white marble, lime-stone, or common chalk, broken into pieces of the size of a

pea, into the bottle *b*, and pour upon it common muriatic acid diluted with two or three times its bulk of water. The carbonic acid gas, which becomes extricated by the action of the acid upon the marble, will pass through the bent glass tube *c*, and enter the bottle *a*, from which it expels the water, and the bottle thus becomes filled with carbonic acid gas. When this has been effected, cork the bottle in its inverted position, with its neck under the surface of the water; and having next removed it out of the basin, pour into it about half a pint of distilled water, cork it again perfectly air tight, shake it for about three or four minutes, and then suffer it to stand for two or three hours, taking care to agitate it during that time frequently. The water will thus become strongly impregnated with carbonic acid gas (or become converted into an artificial seltzer water;) it will send forth a multitude of air bubbles when exposed to the air, and particularly when poured from one vessel into another, or when gently warmed.—The colder the water is, the more carbonic acid gas will be absorbed.

It is obvious that a quantity of carbonic acid gas equal to the portion of water poured into the bottle is wasted; but this is not an object, and this loss may even be avoided, by inverting the bottle filled with carbonic acid gas into a small cup containing distilled water, and suffering it to stand for a few hours, or till a sufficient quantity of the water has ascended into the bottle, and has become impregnated with the gas.

Instead of the glass tube *c*, a common *gas* or *proof bottle* of this shape



may be used, which, in fact, is more convenient than the glass tube *e*. *a* is the body of the gas bottle, into the neck *c* of which is ground, air tight, the bent tube *b*, for conveying the gas into any inverted vessel. The bottom of the body *a* being made round, and of thin glass, will bear a moderate heat, without the risk of cracking.

From marble may be obtained, in this way, from 40 to 45 per cent. of its weight of carbonic acid gas, so that 100 grains will produce between 90 and 100 cubic inches.

LXIV. WATER IMPREGNATED WITH SULPHURETTED HYDROGEN GAS, OR LIQUID SULPHURETTED HYDROGEN.

This fluid, which is not met with as an article of commerce, and which is likewise necessary for the

performance of several experiments exhibited in this treatise (*see pages* 33, 34, 38, 86, 104, 114, 119, 120, 121, 122, 172, 194) may easily be prepared for immediate use in the following manner:

Put into the *gas bottle*, exhibited page 197, one part of sulphuret of antimony of commerce, broken into a coarse powder, and pour upon it 3 or 4 parts of common concentrated muriatic acid, and assist the action of the acid by a gentle heat of the spirit lamp, sulphuretted hydrogen gas will become disengaged from the materials, and which may be made to combine with distilled water, as directed above, for combining water with carbonic acid gas (p. 195.) It is advisable to let the first portion of the gas which becomes liberated escape, because it is mingled with a portion of common air contained in the gas bottle.

Instead of sulphuret of antimony, sub-sulphuret of iron may be used, (but the former substance yields the purest gas.) The sub-sulphuret of iron may be put into the quart bottle *b*, and common muriatic acid diluted with half its bulk of water must be poured upon the sub-sulphuret. Sulphuretted hydrogen gas will be liberated in abundance, and may be made to combine with distilled water, in the manner stated. Distilled water takes up about 3-4 of its bulk of sulphuretted hydrogen gas; and acquires from it a sweetish and very nauseous taste, and strong foetid odour, resembling the smell of putrid eggs, or a foul gun-barrel when wetted. The Harrogate and Moffat waters are natural solutions of sulphuretted hy-

drogen in water. The former contains no more than about one twelfth of its bulk of this gas. Water impregnated with sulphuretted hydrogen gas does not keep for a long time, even when preserved in corked bottles; because the hydrogen quits the sulphur, which then becomes precipitated in the form of a white powder. But for the performance of the experiments exhibited in this treatise, the water, when kept in a dark place or opaque and well corked bottle, retains a sufficient strength for two or three months.

The sub-sulphuret of iron may be obtained by melting together in a covered crucible, for a few minutes, three parts of iron filings, and one of flowers of sulphur; or a crucible may be half filled with common iron pyrites, covered with half its weight of iron filings, and putting over this a layer of charcoal powder, and then exposing the whole to a dull red heat for half an hour.

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